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JAN 30 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.,
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See Illustrated Advertisement Page 81.

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Steam and Electric Cranes,
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SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 637
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Specification and Workmanship equal to Main Line Locomotives.
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Spencer-Hopwood & Kirke PATENT 577
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Mechanical and Structural work undertaken. Special machines and plant designed and supervised during manufacture. Contracts for plant handled for inspection or complete supervision.
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See page 17, Jan. 12. 1134

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Also DIESEL Engines to 1200 HP.
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PHILLOWS BROS., LTD., CRADLEY HEATH, STAFFS. 9158

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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes 817
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 69.

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See Advertisement Page 26. 1111

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Three 60 inch Water-driven Hydro EXTRACTORS by Watson, Laidlaw & Co., Ltd.; new condition.
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Numerous AIR COMPRESSORS, Belt and Steam driven, from 10 ft. up to 2178 cubic feet.
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IF IT'S MACHINERY, SEND US YOUR ENQUIRIES.
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Established 1876.

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&c., &c. 846

Electric Cranes.
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Stills, Petrol Tanks, Air Receivers, Steel Chimneys, Riveted Steam and Ventilating Pipes, Hoppers, Special Work, Repairs of All Kinds.

RAILWAY AND TRAMWAY ROLLING STOCK.
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Head, Wrightson & Co., LIMITED.
See Advertisement page 68, Jan. 12. 2402

Matthew Paul & Co., Ltd. Dumbarton. 763
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See Full Page Advt., page 56, Jan. 5.

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See half page advert., page 57, Jan. 5. 8195

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T. SUMMERSON & SONS, LIMITED, DARLINGTON. 600

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Duckham's Patent Suspended WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD., LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
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For Your Repairs or any SPECIAL MACHINERY, try—
THOMAS HUNT & SONS,
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Drag Line Excavator.
Has moved 2,000 cube yards in one day. May be seen at Frodsham, near Chester. Reach 77 ft.; lift four to five tons; speed of working, one to three cuts a minute.
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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by SIR WILLIAM FAIRBAIRN.

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A sum sufficient to cover the Scholarships now offered has been deposited by the Donors in the names of the Chairman and Vice-Chairman of the Committee.

Candidates must have reached the age of 17 but not the age of 19 on 1st March in the year of Examination, be domiciled in the United Kingdom, and undertake to pursue a three years' Course in Engineering with a view to following it as a Profession.

Papers, which will cover two days' Examination, will be set in the following four subjects:—

English,
Mathematics,
Mechanics,
General Physics.

The Examination for the 1923 Scholarships will be held in March at a date to be fixed later, and all Application Forms must reach the Committee not later than 15th February, 1923.

Full particulars and official Application Forms may be obtained from:—

THE SECRETARY, X 362
Scholarships Committee,
Messrs. NORTON & GREGORY, Ltd.,
1 & 2, Castle Lane,
Westminster, London, S.W.1.

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 575

American University Degrees

(Statutory). B.Sc., D.Sc., and B.Comm. obtained by Thesis written at home.—For particulars send self-addressed envelope (stamped), LAWRENCE (E.), Derwent Street, Leigh, Lancs. X 339

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with particulars of a SPECIAL COURSE of training, will be sent post free on application to DIRECTOR, THE INSTITUTE OF ENGINEERING SALESMANSHIP, 333, Oxford Rd., Manchester. 1119

Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

KETTERING URBAN DISTRICT COUNCIL.

The KETTERING URBAN DISTRICT COUNCIL propose to let a

Contract for the Construction

OF TWO SERVICE RESERVOIRS, at Clover Hill, and of a FILTER BED and a CLEAR WATER TANK, at Cransley Waterworks, in Reinforced Concrete. They Invite Applications from Builders and Contractors who have had experience in this class of work, and are prepared to submit TENDERS therefor.

Applications for the Bills of Quantities and Forms of Tender must be addressed to, and reach me not later than first post on Monday, 22nd January, 1923, and must be accompanied by a deposit of £2 2s. 0d., which sum will be returned on receipt of a *bona fide* Tender.

The Reinforced Concrete Construction has been designed by Mr. B. L. HUNDY, M.Inst.C.E., of Craig's Court House, Charing Cross, W.C.2.

The Drawings and Specification may be seen at the Offices of the Engineer and Surveyor to the Council, Market Place, Kettering.

Tenders, on the Form provided, endorsed "Reservoirs, &c.," must be delivered addressed to me not later than first post on Thursday, 1st February, 1923.

The Council do not bind themselves to accept the lowest or any Tender; and they further reserve to themselves the right to let separate contracts and employ different Contractors for the Two Reservoirs, and for Filter Bed and Clear Water Tank.

JOHN BOND,
Clerk to the Council.

Council Offices,
High Street,
Kettering.
15th January, 1923. X 359

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for

ONE 15-TON OVERHEAD ELECTRIC TRAVELLING CRANE.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 18th January, 1923.

A fee of £1 1s. 0d. will be charged for the specification, which is not returnable.

Tenders must be submitted not later than Noon on Friday, 2nd February, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board, X 390
R. C. VOLKERS,
Secretary.

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,

are prepared to receive

Tenders for the Supply of

1. SCREWS, etc.
2. PORTLAND CEMENT.
3. CANVAS.
4. LINOLEUM.
5. BUNTING, etc.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked: "Tender for Screws, etc.," or as the case may be, must be left with the undersigned not later than Twelve Noon on Tuesday, the 30th January, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 2s. 6d. for each copy of Specification 1, and of 5s. for each of Specifications 2, 3, 4 and 5.

Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
12th January, 1923. X 353

COUNTY OF LONDON.

The London County Council invites

Tenders for the Supply and

DELIVERY in London of about 3300 tons of STANDARD STEEL GIRDER TRAMWAY TRACK RAILS, LIPLESS TRACK RAILS and RENEWABLE GUARD RAILS, with Fastenings therefor, and alternatively, of about 4900 tons of such Rails, with Fastenings therefor. The Drawings, Specification, Bills of Quantities, Form of Tender, and other particulars may be obtained on application to the Chief Engineer of the Council, at the Old County Hall, Spring Gardens, S.W.1, upon payment to the Cashier of the Council of the sum of £2. This amount will be returnable only if a *bona-fide* Tender is submitted and not withdrawn. All particulars may be obtained on application at the Old County Hall before payment of this fee.

Tenders must be addressed to the Clerk of the Council and delivered at the County Hall, Westminster Bridge, S.E. 1, not later than 4 p.m. on Monday, 12th February, 1923. No Tender received after that time will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, X 358
Clerk of the London County Council.

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following PLANT for the Morwell Power Scheme.

Copies of Tender Form and Specification may be inspected or obtained upon application to:—

THE AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 38/9—
TRANSFORMERS and SPARES.

CHARGE.—10s. for first two copies of Tender Form, Specification and Contract Conditions complete.

This charge will be returned on receipt of a *bona fide* Tender.

A third, or any further copies may be obtained on payment of 5s. per copy, not returnable.

PRELIMINARY DEPOSIT.—A Preliminary Deposit of £10 is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed, and addressed, must be delivered to the undersigned in Melbourne, not later than Noon on April 26th, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne,
Australia. X 308

METROPOLITAN WATER BOARD.

TENDER FOR PIPELAYING, REPAIRS, ALTERATIONS TO MAINS, &c.

The Metropolitan Water Board invite

Tenders for Pipelaying,

REPAIRS, ALTERATIONS TO MAINS, &c., within the areas of their Kent, Northern, Southern, and Western Districts, for the periods of six or twelve months from 1st April, 1923.

Tenders must be made on official forms, which may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1, on and after Wednesday, 24th January, 1923, by personal application (Room 155), or upon forwarding a stamped addressed brief envelope. Applicants should refer to the number of the Tender (No. 17).

Tenders, enclosed in sealed envelopes, addressed to the "Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1," endorsed "Tender for Pipelaying," must be delivered at the Offices of the Board not later than Eleven a.m. Wednesday, 21st February, 1923.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Acting Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C. 1.
15th January, 1923. X 369

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification may be obtained or inspected upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place,
Strand,
London, W.C. 2.

SPECIFICATION No. 23/7—
MOTORS, STARTERS and ISOLATING SWITCHES.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third, or any further copies will be supplied for the sum of 10s. 6d. each, not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £40 is required to be lodged with Tender.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed, and addressed, must be delivered to the undersigned in Melbourne, not later than Noon on March 15th, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne,
Australia. X 309

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—

	Fee for Specification.
No. 1—Solid Drawn Steel Boiler Tubes... ..	£1
No. 2.—Straight Axles (Forgings) and Crank Axles (Machined)...	£1
No. 3.—Spring Steel	10s.
No. 4.—Steel Screw Couplings, etc.	£1
No. 5.—Steel Tyres for Loco. Engines... ...	£1

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Solid Drawn Steel Boiler Tubes," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 30th January, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 17th January, 1923. X 384

ISLE OF MAN HARBOURS.

TO DREDGING CONTRACTORS.

The ISLE OF MAN HARBOUR COMMISSIONERS are prepared to receive

Tenders for Certain Dredging

(about 15,700 cubic yards of marly clay, and 3000 cubic yards of schistone rock), to be done at DOUGLAS, ISLE OF MAN.

Copies of the Specification, Form of Tender, and Drawings may be obtained from W. H. BLAKER, Esq., Assoc. M. Inst. C. E., the Engineer to the Commissioners, at the undermentioned address, on payment of £2 2s., which will be returned on receipt of a *bona fide* Tender.

Tenders, endorsed "Douglas Dredging," must be in the hands of the undermentioned not later than Monday, February 5th, 1923.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
A. W. TONGUE,
Secretary.

Isle of Man Harbour
Commissioners' Offices,
Douglas, Isle of Man,
16th January, 1923. X 396

APPOINTMENTS OPEN.

KETTERING URBAN DISTRICT COUNCIL.

CONSTRUCTION OF RESERVOIRS, &c.

The above Council require the

Services of a Skilled Clerk

OF WORKS experienced in Reinforced Concrete work. Estimated period of engagement nine months.

Applications stating salary required accompanied by copies only of three recent testimonials to reach me not later than Saturday the 27th day of January instant.

JOHN BOND,
Clerk to the Council.

Council Offices,
Kettering.
15th January, 1923. X 360

Required, Waterworks Town

SUPERINTENDENT. Must have experience of distribution in all branches, Main Laying, Plumbing work and estimating for same. Some draughtsmanship and keeping of Pipe Plans. Good management of men essential. Population of town 60,000. Age from 30 to 45. Application in own handwriting with three recent testimonials. Salary £300 per annum.—Address, X 383, Offices of ENGINEERING.

Wanted, Works Manager for

works normally employing 80 men, having foundry and machine shop engaged on the production of small Machined Malleable Castings.—Address, X 374, Offices of ENGINEERING.

Sales Manager Wanted by

North East Firm manufacturing Colliery Plant, Engineering Castings, etc.—Apply, stating age, experience, and salary required, to X 382, Offices of ENGINEERING.

Sales-Engineers Required.

One Senior, two Juniors, must have had drawing office experience. Good prospects to real Order Getters. State education, experience, age and salary required.—Address, X 274, Offices of ENGINEERING.

Water Power.—Wanted, for

Water Turbine Department of large Company in London, CHIEF ASSISTANT ENGINEER, experienced in laying out and tendering for Water Power Installation; general knowledge of Turbine design advantageous. State age, salary, when free, previous experience, and attach copies of testimonials.—Write, BOX 633, Advertising Offices, 5, Queen Victoria Street, London, E.C. 4. X 386

Smart Young Engineer

SALESMAN WANTED, 23 to 25. Good education, first-class correspondent. Pulverizing machinery experience as at cement and fertiliser works an advantage. Excellent prospects of advancement for energetic and capable man who proves good salesman.—Address fully, experience, salary, when free, etc., etc., X 389, Offices of ENGINEERING.

THE COMMISSIONERS FOR THE PORT OF CALCUTTA.

Applications are Invited for

ONE EXECUTIVE ENGINEER and for SIX ASSISTANT EXECUTIVE ENGINEERS, with the following qualifications:—

Executive Engineer.—A Civil Engineer who is a Corporate Member of the Institution of Civil Engineers and who has had good experience on Dock Construction, preferably on a Contractors' Staff. Age about 33 years. Salary Rs. 1100 per month rising by Rs. 50 to Rs. 1500 per month.

Assistant Executive Engineers.—Civil Engineers who have had technical education in engineering, are physically fit and energetic, and who have had some experience on Dock Construction. Preference will be given to men who have passed the examination for Associate Member of the Institution of Civil Engineers or hold an exempting degree. They should be unmarried and age about 27 years. Salary Rs. 700 per month rising by Rs. 50 to Rs. 1050 per month.

Applications, with copies of testimonials, to be sent to the undersigned not later than Monday, 29th January, 1923.

J. ANGUS, M.Inst.C.E.,
Consulting Engineer and London Agent.
10, Princes Street,
Westminster, S.W.1. X 381

The Newcastle-upon-Tyne ELECTRIC SUPPLY COMPANY, LIMITED.

STUDENT ENGINEERS.

The above Company is Prepared to Engage a limited number of YOUNG MEN for the purpose of instructing them in the business of ELECTRIC POWER SUPPLY.

The course of Instruction will comprise, inter *alia*:—

POWER STATION OPERATION.
SUBSTATION OPERATION (Rotary and Static).
E.H.T. DISTRIBUTION (including Repairs and Maintenance).
L.T. DISTRIBUTION (including Repairs and Maintenance).
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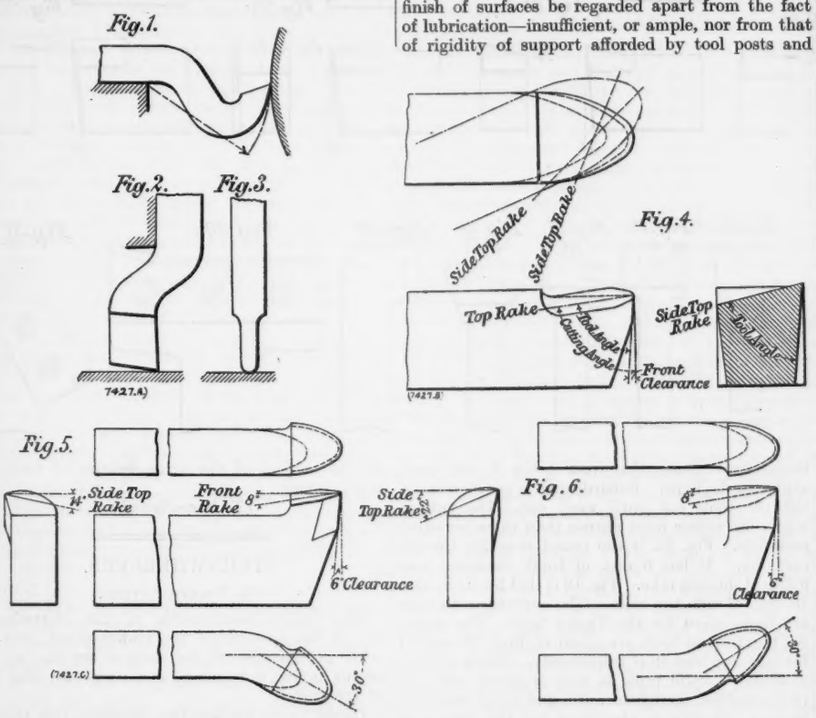
MULTI-CUTTING TOOL ARRANGEMENTS.

By JOSEPH HORNER.

TOOLS antedated machines by thousands of years. The machines are built around the tools which they control and operate. But they have also profoundly modified the forms of the primitive tools, so that it would not be practicable to operate the tools now employed in the machines by hand labour. Machines and their tool equipments are therefore inseparably associated, and in a large degree stereotyped and standardised. The search for high tool efficiency has advanced in two directions, that of individual design and formation, which has been the subject of countless experiments, and that of the multiplication of tools in simultaneous action. The first is of very high importance, but it is being in some degree overshadowed by the second. This statement does not for a moment call in question the cardinal value of the first, but simply states a fact that is not open to question. Actually, one is the complement of the other, since the present multiplication of tools would not have been practicable apart from the knowledge of the provisions necessary to secure the efficiency of individual cutters. It may be well therefore to give a brief account of the tool formations that are now recognised as of high efficiency in the most advanced practice of the present.

The Standardisation of Tool Angles.—No allusion need be made to the countless experiments that have been made with cutting tools having angles that are never adopted in the shops—tools that possess no endurance of edge. The essential fact now is, that, in harmony with the standardisation which tools share in common with other items of practice, variations in angles are usually limited to three—two sets of angles only for all true cutting tools, and one set for the scrapes. This is done to simplify the task of grinding performed in the tool room. It avoids the minute variations which are always found in those older shops in which men still grind their own tools, some of which variations are desirable for dealing with certain grades of metal, and classes of work. But some are detrimental, detracting from the endurance of the edge, as when an excessive amount of top rake, and front clearance are given to tools that have to cut the harder grades of metal. Long years ago, Smith and Coventry advocated the use of two sets of tool angles only, with round stock held in tool holders to cover all grades of metal. Since that time the same view has been advocated and applied by Taylor, Sellers and others, and is generally adopted. Associated with these are the curves imparted to the round-nosed tools—the blunt, and the sharp, and the giving side top rake to the cutting edge, in two sets of angles.

The true test of a cutting tool is the removal of the maximum quantity of material, with that prolonged endurance of the edge which avoids too frequent regrinding. Associated usually with this is the leaving a suitable finish on the work—a matter of no moment when the finish is imparted with a second tool, or with a grinding wheel. Tools are frequently classed as roughing, and finishing, but this distinction is far from being universal or even general now, since many tools both rough and finish, these being a development of older tools with two edges, one leading, the other following. Neither can the efficiency of tool angles, nor the smooth finish of surfaces be regarded apart from the fact of lubrication—insufficient, or ample, nor from that of rigidity of support afforded by tool posts and holders, and the stiffness of build of machines in which the tools are operated. The materials used for the tools affect efficiencies, *e.g.*, carbon steels, high-speed steels, and stellite, each being employed now in nearly every design of cutting tool made.



Old and Later Tool Shapes Compared.—Figs. 1 2 and 3 merely illustrate a dying practice—the old cranked tools used in lathe, planer and shaper. The idea was that the tool would not hitch in the work, being thrown off around the arc struck from the supporting edge of the tool rest or the tool box. These tools are straightforward, so that when Fig. 1 is used in the lathe it does not cut laterally in the direction of feeding, because the cutting angles lie in the axis of the tool. Nearly all the later tools have the effective angles disposed to one side of the axis, the reason for which is as follows: When a turning tool is ground absolutely straightforward, that is when its cutting angles lie only in the axis of the tool shank, it is inefficient unless it is set at a plan angle with the work that corresponds with the direction of feed. The reason is that the angles which lie elsewhere than in the axis are less than those in the latter. The turner, when using a straightforward tool sets the shank at an angle that corresponds with the direction of feed, so employing the real tool angle for cutting. Or the tools are cranked or bent for left- or right-hand feeding. A side top rake was often ground on the old tools. Similar provisions are made now, but embodied in standards. In these, two forms of tools are recognised, the straightforward, and the bent, to left- and right-hand, and all have side top rake.

Tool Angles Defined.—Only one angle in tools is of a fixed character from which others are measured—that of front clearance or rake, Fig. 4. This need not vary from 5 deg. or 6 deg., since its sole function is to prevent severe friction between the front of the tool and the work. More than this is commonly given to hand-ground tools, but it diminishes the durability of the tool point, without corresponding advantage. Two angles are shown, that at which the tool is forged, and the grinding angle, of less width, with a reserve for grinding back, and to save time. The cutting angle is that measured from the face of the work, or its tangent if circular, to the angle of top rake. The tool angle is equal to the cutting angle minus the front clearance. It is determined by the absolute strength required, and by the necessary slope of the top rake. Strength is essential to heavy cutting, and top rake enables the chips, or the shavings to be cut off with an incisive wedge-like action, instead of being torn off. When the angle of the top rake is large, as it is for dealing with wrought iron, soft steels, copper, &c., unbroken shavings roll off and slide down the top face of the tool. When the hard, crystalline metals and alloys are being turned, the chips are broken as fast as severed, and the laminæ slide on one another. When no top rake is imparted, as in most tools for turning brass, and in the majority of finishing tools, and in many milling cutters, the chips are ruptured and comminuted.

The amount of top rake therefore has to be related closely to the character of the material being cut. It controls the tool angle, but the latter must not be weakened unduly. This may range anywhere between 50 deg. and 80 deg. at extremes. The standardisation of these angles is now generally confined to two sets. Each has the same front clearance of 6 deg. For turning hard steel, and cast-iron, the top rake, Fig. 5, is 8 deg. from the horizontal, and the side top rake 14 deg., giving a tool angle of 70 deg., and a cutting angle of 76 deg. The top rake, and clearance are unaltered for the softer steels and wrought iron, but the side top rake, the real working angle is increased to 22 deg., giving a tool angle of about 62 deg., and a cutting angle of 68 deg., Fig. 6.

In a standard system, as in the Taylor, and Sellers, these tools are made straightforward, right- and left-handed, Figs. 5 and 6, and bent to 30 deg. in plan, also right, and left hand, and each in the two sets of angles. Another difference made is that of the radius of the round nose in plan, the tools being divided into a blunt group for cutting cast-iron and hard steel, and the sharp group—that with curves of lesser radius, for wrought iron, and mild soft steels. The Taylor formula is: Let the width of the tool shank = A, the radius of the nose = R. Then, for the blunt tool, $R = \frac{1}{2} A - \frac{5}{32}$ in., for the sharp tool, $R = \frac{1}{2} A - \frac{1}{16}$ in. These differences though not formulated thus have always been made by turners. A difference is now made in the depth on the tool shanks. Instead of being square, the depth is $1\frac{1}{2}$ times to twice the width, Figs. 5 and 6. This enables them to withstand heavier cutting, and is preferable to the cranking of the square shanks in Figs. 1 and 2.

Tools for Roughing and Finishing.—A variation in the old and the new is, that while the two operations of roughing and finishing are necessary, less difference is made in the shapes of the tools used for each. The old spring tool, carefully oilstoned, and cherished by the turners of a past generation has disappeared. Commonly now the tool that roughs, or one of the same shape, also finishes, using a higher speed and coarser feed. Especially is this so when the straight-edged knife-like tools are employed. These often rough and finish at one traverse, the front edge cutting deeply, the leaving edge smoothing. These are sometimes grouped as tools having double edges. The regular finishing tools are largely limited to profiled forms, for which they are indispensable.

The Double-edged Tools.—The changing of roughing for finishing tools is not very objectionable when work is long and parallel. But it is undesirable when work is stepped in different diameters, and with collars, shoulders and flanges. Each portion then has to be roughed and finished. This, in the common lathe, employing two sets of tools, is wasteful of time. The tool formations just described provide

for finishing as well as roughing. But they cannot finish to shoulders, for which another class of tools is employed, to be noticed presently. The provision of side top rake is equivalent in action to that of the old double-edged tools in which the leading edge roughs, and the following edge finishes. A round nose tool, cutting straightforward, and fed laterally leaves a series of spiral ridges on the work. A round-nosed tool having a good curvature in plan, and side top rake roughs with the leading edge, and finishes with the edge following, which obliterates the ridges left by the first. The old graver, the essential form of which is retained in some of the bent tools to-day left a fine finish on the work because the following edge smoothed down the ridges produced by the leading edge. The round-nosed tool of large radius, while more incisive, produces similar results. Nearly all the material is removed by the leading edge, while the following edge smooths the roughnesses. All the stress of cutting is borne round the leading edge, where the real cutting angle is situated, and the finish is imparted by that section of the tool where the angle is considerably less, so that theory harmonises here with practice.

Figs. 7 to 12 illustrates a range of curvatures of round-nosed tools. Figs. 7 and 8 are of no use for heavy roughing. They are employed for rapid, shallow cuts, and fine feeds. If without top rake, they are forms employed for brass and gun-metal. Fig. 9 is a good roughing tool, which if ground straightforward should be set in the direction of feeding. Figs. 10 and 11 are good for roughing, especially if they have side top rake. Fig. 12 shows how these tools will both rough and finish. They cut deeply in the direction of feeding, but little is left for removal in the radial direction with the following edge. In heavy cutting, the advantage of lateral cranking is manifest, since the enormous pressure exercised on the tool by coarse chips is taken on the axis of the tool point, instead of exercising a lateral pressure on the shank.

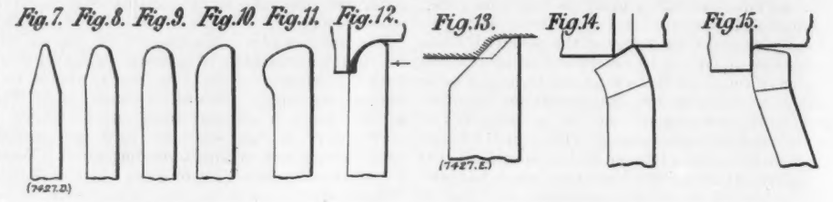
Tools with Straight Cutting Edges.—Though the round-nosed tools are standardised, their employment is far from being universal. Other forms supplement or supplant them, the growth of these being largely a consequence of the introduction of the high-speed tool steels. Many of these have no curvature, but are simply double-edged tools of great substance and rigidity. Some are illustrated, leading up to the knife tools that take broad shavings with shallow feeds, and which both rough and finish. Fig. 13 is a double-edged tool, cutting deeply on the leading edge, and finishing with that following. Fig. 14 produces a similar result but neither will finish to a shoulder, which Fig. 15 will do, in addition to roughing and finishing. Fig. 16 resembles it. Fig. 17 is one of the knife tools, used largely in turret lathes, and for general service where turning has to be done to a shoulder, which is the case with a large proportion of work.

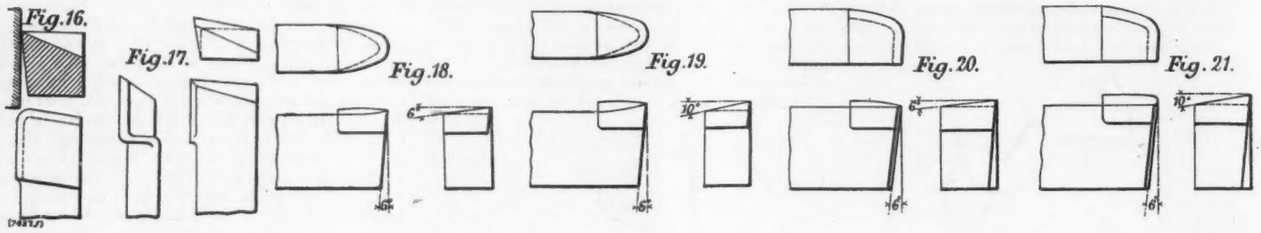
Stellite Tools.—These have steel shanks, to which tips of stellite are welded. They will cut at a full red heat, the heat increasing the strength, the best temperature being that just below a red heat, visible in daylight. Rehardening is not necessary, but the tools cut until worn out. The cutting angles are rather more obtuse than those for other materials. Fig. 18 is the round nose for turning cast-iron. It has 6 deg. of front clearance, and 6 deg. of side top rake. Fig. 19 is that for steel, with 10 deg. of side top rake. The curvatures in plan are those given for the Taylor tools. The angles for blunt-nosed tools are given in Figs. 20 and 21 for cast-iron and steel respectively. Besides these, a series of knife tools is also prepared that cut to a shoulder, straightforward, and right- and left-handed. Stellite is also used for the blades of milling cutters, for boring tools, and those fitted in tool holders.

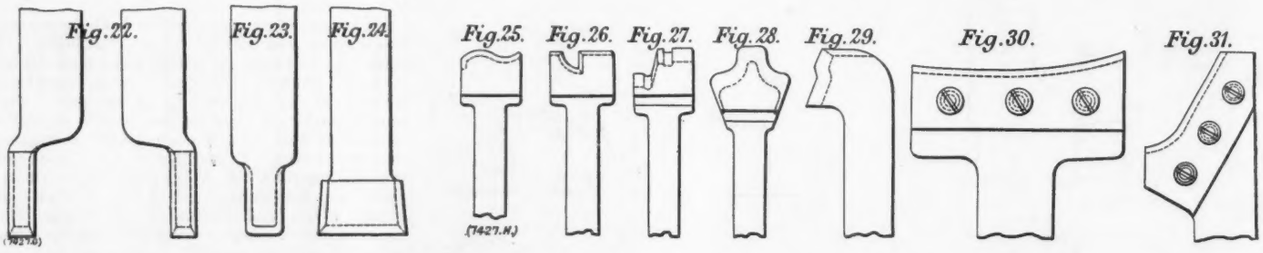
Forming Scraping Tools.—There is a very large field in which the strictly finishing tools do not lessen, but increase in importance, that of form-turning, and form-profile cutting of various kinds, done in common lathes, but much more extensively in turret lathes and automatics, and vertical-boring mills. With few exceptions these are all scraping tools, that is they have no top rake—a matter of little importance, because the amounts to be removed are generally minute. The provision of top rake would, in many of these tools give occasion to great, almost insuperable difficulties in grinding the hollow faces that would be necessary.

Typical of these tools are those used for parting-off and grooving; Figs. 22 to 24. These are slightly narrower at the hinder part than in front, to enable them to cut without severe friction. They have front, and side rake, as indicated by the dotted lines. Generally when the outlines are plain as shown, a slight amount of top rake is imparted for iron and steel, but not for brass, into which a tool with top rake is liable to dig. Various form tools, such as are used in the cross slides of turret lathes are shown in Figs. 25 to 29. They have front clearance only, seen dotted. They are forged solidly on square bar. Figs. 30 and 31 are forming tools of steel cutters screwed on their bars, with front clearance only. Tools of which these are typical occur in an unlimited number of shapes, being made to suit whatever work is in hand. The principles that have been stated above apply to drills, boring tools, milling cutters, &c., in each of which cutting, and scraping, with rake and clearances are present in various degrees. In our next article we shall take up the subject of the arrangements of tools for multi-cutting.

(*To be continued.*)







STERNWHEELERS.

By JOSEPH IRVING.

THE chief characteristic of the sternwheeler lies in the position of the paddle-wheel, and all other peculiarities of the designs are due to the engine having to be placed at the extreme after end of the vessel.

Owing to its peculiarities, however, this type of vessel possesses certain advantages over the ordinary paddle boat, although, like all other advantages, these have to be bought at a price.

For instance, the engines being so far aft necessitate the boiler being placed well forward to maintain an even keel. This has the advantage that the whole of the midship portion of the vessel is free for the stowage of cargo or the fitting of cabin accommodation as may be required, but the objection is that the steam pipe and also the exhaust pipe in non-condensing vessels, or the feed pipe in condensing sets must be of abnormal length.

Again, owing to the two heaviest weights being placed at the extreme ends of the structure, and to the fact that these vessels are usually of small depth of hold, sufficient fore and aft strength cannot be obtained without constructing a certain amount of girder work above the level of the main deck. This interferes in some cases with the free passage of cargo to and from the shore.

The paddle wheels or wheel being wholly contained within the width or beam of the vessel are not exposed to damage as in side wheel vessels, and do not add to the effective width of ship, which is a great advantage in navigating narrow and tortuous channels.

Sternwheelers naturally divide themselves into three broad classes according to the purposes for which they are required, and customs and restrictions of the rivers on which they are used.

Firstly, there is what might be called the British type, for although there are no sternwheelers in use in this country a very large number are built

here for service on the rivers of Africa, Mesopotamia, India and various other countries. These vessels are usually of very shallow draught, and are used for the conveyance of passengers, officials and cargo, sometimes towing one or two small cargo flats or barges alongside, but not in any sense to be regarded as tugs.

Secondly, there is the German type as found mostly on the Elbe and Oder, and their tributaries. On the upper reaches of these rivers the depth of water available is too small for screw tugs, and the locks which must be passed through are too narrow for paddle steamers, therefore the sternwheeler with its shallow draught and narrow beam, is the only type of vessel which will meet the requirements. These vessels are essentially tugs, and are fitted with very high powers for towing heavy barges against the current.

The third class is the American type as used on the Mississippi, Ohio, Hudson and other rivers of the United States. These, like the German vessels, are tugs, but whereas the German boats have to take their heaviest loads up against the stream, the American craft handle their tows down with the current and consequently the method of towing is quite different. In Germany the tugs tow the barges astern in the usual way, but in America the steamer pushes the load in front of her. The barges are all securely lashed together and the steamer is secured to the whole, and thus there is one huge raft with the sternwheeler acting as the main engines and rudder at the after end. These American sternwheelers have immense rudder power, but it is of course impossible to steer an unwieldy collection of barges straight ahead all the time, and these boats have to be constantly stopping and going astern to manœuvre their tow past the bends and other obstacles. It is said that these vessels are backing for about one-fifth of the time they are under way, and it is the good steering and backing qualities of the sternwheeler that make them so suitable for the work required on the American rivers.

The whole success of a sternwheeler depends on the correct design of the hull lines at the stern, the arrangement of the paddle wheels and rudders, and the structure provided aft for supporting the heavy weights.

Usually the stern line in plan is square across the ship, the deck line does not run in at all and the buttock lines all rise up under the stern on the same curve. As the midship section is practically square this means that the bottom of the vessel rises up until it meets the deck, and the side plating is tapered off accordingly. The whole secret in this case lies in the correct buttock line. If the line be made too fine there is a loss of displacement and longitudinal strength just where both are required, and if the line be made too full then the flow of water to the wheel is interfered with, and this is more serious in going astern than in ordinary ahead running. There should be no flat plate on the end of the hull at all, or serious interference will occur when the engines are going astern, but the buttock lines should run right up to the deck.

One vessel, which was built with a very full stern line and a flat square end, had the wheel so close up to the stern that, when the engines went full speed astern the vessel went slowly ahead.

That shows also that the paddle wheel should be kept well aft the forward edge of the floats, being about 15 in. to 18 in. away from the after perpendicular for successful working. This has, of course, the disadvantage of throwing all the paddle wheel, shafting and plummer block weight further aft than would seem to be absolutely necessary, with a consequent increase in weight of the supporting steelwork, but the disadvantage of unduly crowding in the wheel is well exemplified in the instance just given.

In some cases the paddle wheel is split and the engine fitted on the centre line between two wheels. It then becomes possible to build an extension of the hull aft between the wheels which gives added strength and displacement underneath the engine, and this is often done. The extended part may end in a similar stern to that described above, or it may be fined away to resemble a square sterned lifeboat. In the latter case a certain amount of displacement is lost, but it is a better stern if a rudder is to be fitted right aft. A disadvantage of this type is that the paddle floats are much nearer the sides of the ship, and in narrow rivers and channels are more liable to damage.

With the ordinary square stern without the extension, three rudders are usually fitted immediately forward of the wheel, and a very powerful steering effect is obtained both ahead and astern.

When going astern all the water from the wheel is forced on the rudders, and when a vessel of this type runs her bow aground it is possible by moving the rudders from port to starboard and back again to cause the stern of the vessel to swing from side to side so that she gradually backs off. At the same time a powerful stream of water is being forced under the boat, and this has the effect of scouring the sand away and deepening a channel. The rudders are usually of the balanced type made of wood, and except in the very largest vessels, hand-steering gear only is fitted.

The overhanging steelwork fitted aft to carry the wheel is sometimes built up as an extension of the side plating and the fore and aft girders in the hold, and this arrangement has a very neat appearance, but it is much simpler in every way to provide rolled steel joists or channels fitted on top of the deck and overhanging as far as necessary to carry the main bearings, these can then be used in the shop to erect the engines on, with a consequent reduction of the work to be done on the ship when building abroad. These rolled steel sections should be straight from end to end as if they are fitted on a curve for appearance it is sometimes very difficult to line up the four of them to the same line when cylinders, guides and main bearings are all fitted direct to them at different points on the length.

In a vessel with one wheel and an engine on each side, only the two inner beams are carried out to the bearing, the outer ones, of course, stop at the end of the deck. When the engines are fitted on the centre line, the problem is much simpler, but even then the outer bearings must have beams carried out to support them. A vertical strut is usually erected at the after end of the hull, in line with the engine beams which carry the main bearings and a diagonal tension rod with tightening screw is fitted from the top of the strut to the outer end of the engine beam. Sometimes also a second tension rod is fitted to a point on the beam just forward of the main bearing. The top of the strut is also tied forward to the main girder work and down on to the deck by further tension rods or angle bracing. It is very important that these tension rods should be properly adjusted, as on that adjustment depends both the fore and aft and thwartship alignment of the main engines.

In addition to the beams required to support the wheel and engines it is usual to carry angles to take a wood fender right round the wheel in continuation of the rubbing piece at the deck line, and sometimes also a gangway is fitted aft of the wheel for access to the floats, with a hand rail right round. This latter, however, is of very doubtful value, as it is of course impossible to do anything when the wheel is in motion, indeed it is not possible to even walk round without getting drenched, and when the wheel is stopped and properly secured, any work on a float can be done by standing in the wheel and on the other floats. It should be further remembered that all extra weight fitted in this overhanging structure not only detracts from the naturally limited carrying capacity of these vessels, but also requires that the boiler must be pushed further into the bow to balance it. The bow lines of sternwheel steamers vary from the proper ship-shaped bow with a straight stem to the full spoon bow with no stem at all. The first is usual when speed is more important than minimum draught, but a very good type is what is known as the semi-spoon bow. This is very like the spoon bow, but instead of the water lines being brought to a line at right angles to the ship at the centre line, they run in to a very blunt point.

In some cases, mostly in America, the deck at the bow is carried out on struts beyond the hull to form a square sponson deck forward, and this is used for loading and unloading purposes.

In the British type, however, the whole of the fore end of the boat is usually occupied by the boiler, a capstan or windlass, and the anchors and chains. The anchor and its capstan is much more important on a vessel of this kind than would at first sight appear probable, owing to the fact that it is used for warping the vessel off sand banks and sometimes over them, and it is necessary in shallow rivers where the channel is constantly shifting to have sufficient working space round the capstan for its efficient working at full pressure on very short notice at any time.

On these occasions the capstan is usually assisted by the spare hands of the crew, who jump overboard and push against the side of the vessels.

The longitudinal strength of the sternwheelers is maintained partly by the sides of the ship and partly by fore and aft lattice girders built in the hold. There is very often a solid bulkhead the whole length of the ship on the centre line, and sometimes partial bulkheads at the sides as well. The depth of hold, however, is so small in proportion to the length that it is necessary to adopt other means to stiffen the structure. Vertical struts are erected at intervals along the deck on both sides, carried down through the deck to the bottom and attached to the floors and, as far as possible, to the thwartship bulkheads. The tops of these struts are usually connected to the stringer plate of one of the upper decks, and this forms the tension member of a lattice girder. Diagonal bracings are fitted between the struts sometimes of angle, sometimes of round rod, and sometimes in the American vessels of chain. This girderwork extends from the tie rod supporting the wheel to a point far enough forward to support the boiler weights.

One of the fore and aft girders in the hold should be fitted in line with the main engine seat beam which carries the bearing, and the vertical struts for the main girder are sometimes fitted on this fore and aft line also. This means that the upper deck beams will be slightly overhung, but they can easily stand that, and a clear space without stanchions is provided along each side of the main deck, which is a great advantage.

It is very important that the design of this longitudinal girder work should receive very great attention, and there is a great deal to be said in favour of the system of making the main diagonal bracings of round rods fitted with tightening screws. It is obvious that if the vessel is to carry her maximum deadweight at any draught, she must be flat on the bottom and neither hogged or sagged. If the centre of the vessel hogs up even 1 in., that represents so much cargo shut out, as the ends of the vessel will be at the maximum permissible draught before the midship portion. That is a point which is sometimes lost sight of, but it should always be remembered that all shallow draught river steamers work to a maximum draught, not a mean.

The longitudinal strength of the hull proper being small, it follows therefore that if the main girders are fitted with adjustable tension rods then the general shape of the hull can be adjusted as required when the vessel is built, and also later on if any deformation takes place.

The hulls of shallow draught sternwheelers as built in this country are usually of galvanised steel, of very light scantlings, and generally every effort is made to keep the weights of hull, engines and boilers as low as possible. The result is that the average light draught of these vessels with boilers full is from 18 in. to 24 in., and the loaded draught is limited solely by the water available, but is seldom much more than 3 ft. The main deck, which is, of course, part of the hull structure, is often of galvanised chequered steel plates. There is usually an upper deck carried up on stanchions, and sometimes a flying deck as well above that, also on stanchions, and there is always what naval architects call a sun deck, but what is in the tropics more commonly called a roof. This is sometimes of light corrugated iron, but more usually of wood covered with canvas and painted. The upper decks, which are the passenger decks, usually have a certain amount of cabin accommodation, which is as a rule rather heavy because for tropical service all woodwork must be teak. Also all the cabins are fitted with glass windows, venetian or jalousie shutters and mosquito screens.

The outfit of anchors and chains is usually rather heavy, and taken altogether it is a very creditable performance to get a vessel of this description to

carry any cargo at all in a draught of water which does not take an average man over his knees.

The shell plating is usually about ½ in. thick, sometimes less in the smaller vessels and should be made slightly thicker round the bow, as this end has to stand all grounding and beaching strains. It is quite common to see these vessels with the shell set up between all the frames on the bottom, and it is very difficult to avoid this without making the shell plating too heavy.

Sometimes wood sheathing is fitted round the bow as a protection and bilge keels just on the turn of the bilge, where much of the worst damage is liable to occur in a sideways grounding. Hold space being very broken up with stiffening, most of the cargo is generally carried on deck, and it is very important that the deck beams should be strong enough. The unsupported span is, of course, only that between the rows of fore and aft girders and bulkheads in the holds, and even this should be reduced as much as possible by the provision of long thwartship plate brackets fitted on every vertical member of the lattice girders and on every vertical stiffener on the longitudinal bulkheads.

In cases of vessels being shipped in plates and bars for re-erection abroad, the shell plates should all be packed in crates, and the straight angles and frames baled or otherwise protected, as very great damage is often suffered by these light plates and angles unless adequate precautions are taken. No damage is done on the long voyage, it is the transhipments that cause the trouble.

As a rule the parts are first of all loaded into railway wagons at this end, then transferred to the ocean steamer, then discharged into lighters, and finally unloaded at point of destination; in all, four handlings as a minimum, sometimes many more, depending on the accessibility or otherwise of the place where the vessel is to be built.

In some cases the weight of packages must be kept very low for coolie transport, and the greatest difficulty then is the boiler which must be sent out in sections, and sometimes two small boilers are fitted for this reason alone instead of one large one.

The German vessels are also built of steel and also work in very shallow draught, but the requirements are rather different and much more easily fulfilled. These boats are essentially tugs, and have no upper decks or roof. The hulls are made much deeper, and sufficient longitudinal strength is obtained under deck so that there is no top hamper of any kind. The engines, boilers and cabins are all fitted under the deck and completely closed in, and the wheel also is covered over with a light casing. The result is that the scantlings can be made rather heavier than the British type and still allow of cargo being carried on the same draught.

In the American vessels the requirements are different again. The almost universal practice is one upper deck and a roof, but the draught varies from 3 ft. to as much as 5 ft. 6 in., with the result that these vessels, which are often built of wood, are much stronger and stand more knocking about than the type of vessel built in this country. The Mississippi tugs sometimes handle as much as 50,000 tons in a single tow. The girder work above the deck is fitted in these vessels, but the compression members are usually of wood, and the tension member chain—hogging chains they are called. This type of vessel has been built on the Mississippi for the last fifty years without much change of details or general design.

(To be continued.)

AN ELECTRICAL METHOD FOR MEASURING THE VELOCITY OF MOVING WATER.

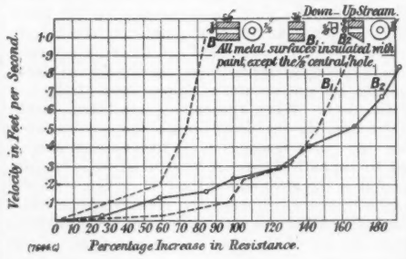
By M. A. HOGAN, Ph.D.

THE Department of Scientific and Industrial Research published in June, 1922, a report on Current Meters for use in River Gauging. In paragraph 27 of this report mention was made of an electrical method for measuring currents at low velocities. This method had been developed in America, and the particulars given were taken from a paper by Mr. W. S. Cleverdon in the *Scientific American Supplement* of February 2, 1917. This method appeared to deserve further investigation, and the author has made some experiments at the request of the Committee of the Department dealing with the matter. The Department considers that the following notes may be of general interest.

I. *Summary of Cleverdon's Paper.*—Cleverdon's work commenced with the observation that the resistance to the passage of an electric current between two electrodes immersed in water depends on the velocity of motion of the water. Further observation showed that although the resistance for the same velocity was increased by separating the electrodes along the direction of flow, this increase in resistance was not proportional to the increase in distance. The resistance increased much less rapidly than the distance, which suggested that the principal seat of the resistance was at the electrode surface where the current passed into or out of the water.

This hypothesis was borne out by the fact that different shapes of electrode exhibited different resistance phenomena. With some types of electrode, the increase in resistance for a given velocity of flow was several times as large as the increase shown by other types. Fig. 1 shows a few of the most efficient electrodes used. In each, the actual conducting surface was the cylindrical hole in the axis, all other portions of the metal being coated with insulating paint. The same figure also gives the results of tests on these electrodes. It will be seen that, particularly in the case of B_2, the resistance increases almost uniformly with increase in velocity up to about 0·5 ft. per second, and that the velocity has still quite a marked effect on the resistance up to about 1 ft. per second. Hence it was concluded that an electrode of this type would be a suitable instrument for the measurement of water velocities up to about 1 ft. per second.

Fig. 1. INCREASE IN RESISTANCE WITH FLOW (CLEVERDON).



Experiments made with waters of different conductivities and with salt solutions showed that if the resistances measured at various velocities be expressed as a percentage of the resistance at zero velocity, then these numbers remain the same for the same velocity, irrespective of the absolute conductivity of the water.

II. *Work at South Kensington.*—The results of Cleverdon's work seemed so promising that it was decided to make a further study of the phenomena involved with a view to rendering the method of practical utility. Experiments were made in the hydraulic laboratory of the Imperial College at South Kensington on electrodes of various shapes exposed to water flowing in pipes from 4 in. to 10 in. in diameter. A few trials were also made of the effect of towing the electrode through still water.

In the case of the experiments on electrodes in pipes the velocity of the flow was determined, indirectly, from the quantity of water passing, which was measured in a tank or over a calibrated V-notch. The electrode was usually exposed at the centre of the cross-section, and the velocity at that point was assumed to be 1·2 times the mean velocity over the whole section. This factor was derived from experiments made with the Pitot tube at moderate velocities (2 ft. per second and upwards). If, however, the velocity of flow in the pipe were below the critical velocity, so that the flow was viscous, the axial velocity would be twice the mean velocity. At the very low flows used in these experiments it is possible that the velocity was sometimes less than the critical and that thus the factor 1·2 used to derive the axial velocity was too low. This would cause the computed velocity to be 40 per cent. too low. The measurements of resistance were made by means of an ordinary Wheatstone bridge. For the alternating current tests a simple slide wire bridge with coil and telephone was used. The measurements of potential were made with a Crompton potentiometer, a Clarke mercury cell being used as standard.

The first experiments were made in an 8-in. diameter steel pipe, using two ⅛-in. diameter brass wire electrodes, 1 in. long, placed at right angles to the direction of flow, across the axis of the pipe, and 2 ft. apart. When a current was passed through the electrodes, with the water at rest, using a battery of four dry cells across the bridge, it was found that the resistance of the electrode gap increased at a gradually diminishing rate until it was upwards of 60 per cent. greater than the initial value. When the water in the pipe was set in motion the resistance decreased to about half of its initial still water value. Similar results were obtained using copper instead of brass. In both cases a deposit of copper was noticed on the cathode.

It was suggested that the polarisation troubles might be decreased by using for the electrodes a metal, such as iron, which was already present in solution in the water. A pair of iron wire electrodes were accordingly set up, and it was found that, using four cells across the bridge, the resistance increased by about 8 per cent. when the water was set in motion. However, this change was masked by a steady increase in the resistance due to polarisation. When only one dry cell was used, the resistance decreased to half its still water value, when the water was set in motion. However, this still water resistance did not remain constant, but kept on increasing slowly all through the tests. On separating the electrodes to a distance of 10 ft. apart the previous results were duplicated. Since the use of iron electrodes did not remove the polarisation troubles, it was decided to eliminate all electrolytic actions by the use of an alternating current. Tests on the various pairs of electrodes showed that the resistance, when measured by an alternating current, was independent of the motion of the water in the pipe.

Experiments were now made using a single electrode with the pipe as return. Using one cell, it was found that no velocity effect was developed when the electrode acted as anode, but only when it was cathode. With a number of cells it did not matter whether the electrode acted as anode or cathode. Polarisation proved still very troublesome with a single cathode. Many trials were made to see if the alternating current resistance would be affected by motion of the water, but with a negative result.

Since the resistance to an alternating current is unchanged by motion of the water it becomes evident that the changes observed when a direct current is used must be due in some way to polarisation. That is, the changes in resistance observed when the water is set in motion must be due to the removal or liberation of the products of electrolysis. The quantitative development of polarisation for any electrode is dependent on the magnitude of the external electromotive force, and thus it became of importance to study the connection between the applied e.m.f. and the resistance phenomena.

Using a brass cathode, ¼ in. diameter and 1 in. long, across the axis of the 10-in. pipe, the effect of gradually increasing the e.m.f. on the resistance was tried. (See Fig. 2.) Commencing with a very low e.m.f. the resistance increased with increase in e.m.f. up to a value of about 0·8 volt, when conditions became unstable and the resistance commenced to diminish again. The experiment made in still water was repeated with moving water, and it was found that the results were similar, save that the value of the resistance corresponding to a given e.m.f. under moving water conditions was only one half of what it had been under still water conditions. When the voltage was increased over 0·8 volt the resistance diminished, but the rate of decrease became very small at 4·5 volts. In this area the tendency was for the moving water resistance to be greater than the still water value. However, the region between 0·8 volt and 1·5 volts was one of great instability, and no reproducible results could be obtained therein. Below 1·1 volts the moving water

resistance was less than the still water resistance, while above 1·1 volts it was greater. Above 1·5 volts the conditions seemed to be more stable and the resistance in moving water decreased gradually with increase in the applied e.m.f., but, for any value of the latter, the resistance in moving water was about 10 per cent. greater than the still water resistance.

This experiment shows that the discrepancies between the results of the previous experiments and those of Cleverdon were due to the different values of the applied e.m.f. used in the two cases. In the subsequent tests on electrodes of various shapes a battery of four or five cells, giving an e.m.f. of 3 volts or 3·75 volts across the electrode, was used. When using an electrode similar to this, type B, the maximum increase in resistance observed was only 43 per cent. as against 85 per cent. (see Fig. 3). Also, in Cleverdon's experiments this increase took place fairly gradually, whereas in the present experiments the increases in resistance almost all took place below a velocity of 0·1 ft. per second. Other electrodes gave similarly discordant results.

It was thought that perhaps the size of pipe might exercise an influence on the results. Cleverdon used a 3-in. pipe. The tests on type B were repeated on a 4-in. pipe, but the increase observed was then only 20 per cent., or half that obtained in the 10-in. pipe. In stating that the increase of 20 per cent. was only half that observed in the 10-in. pipe, it is to be noticed that, in three consecutive runs, the increases observed in the 10-in. pipe were 43 per cent., 37 per cent. and 28 per cent., respectively, so that the term half only applies to the initial run in the 10-in. pipe. This would seem to indicate that the size of the pipe is unimportant.

To see if the presence of the pipe were necessary for the development of the resistance phenomena, a few experiments were made in the current meter-rating channel. The channel is 5 ft. wide and contained a depth of 2½ ft. of water at the time. An iron pipe, 1 in. diameter and 5 ft. long, was laid along the bottom of the channel to act as anode, while the cathode, immersed to a depth of 6 in., was towed along on the carriage. It was found, using one cell, that the resistance diminished when the electrode was moved through the water; while with four cells, the resistance increased when the electrode was moved. The magnitudes of these changes in resistance corresponded fairly well with those observed for the same electrode in a pipe. This establishes the fact that the electrode is the seat of the resistance change.

All through these experiments it has been exceedingly difficult to obtain a repetition of any measurement. The resistance, and the power to undergo change in resistance, of any electrode is a function of its previous history, and even a few minutes quiescence suffices to produce very large changes. Hence it would appear that, as at present applied, the effect of moving water on the resistance of an electrode is too variable to form the basis of a measuring device.

III. *Explanation of the Results.*—An attempt has been made to find some theoretical explanation of the observed phenomena, but with little success. In the first instance, it is advisable to examine the suggestions put forward by Cleverdon as to the cause of the phenomena which he observed. From a series of tests on different shaped electrodes he reached the following conclusions:—

"(1) Where the electrode is long andn arrow, like a knife blade, and points in the direction of flow, there is little change in the resistance for any velocity of water flow, since the water keeps in contact with it over its entire length.

"(2) Where the electrode is wider and suddenly terminates, there is a tendency to form a partial vacuum at this point, reducing the area of contact between the electrode and the water, and thereby increasing the resistance."

It is not very clear what is meant by the term "partial vacuum." On the down-stream side of an obstruction there may be either a region of dead water or a pocket of gas. The dead water would be quite as efficient a conductor of electricity as the moving water, and hence could cause no change in resistance. The gas pocket, on the other hand, would act as an insulator to that portion of the electrode surface with which it was in contact. In this explanation it is implied that the gas or gases have been liberated from solution in the water by the reduction in pressure below the obstruction, and that they are in no way concerned with any electrolytic action. Granting this, it is evident that the pocket of gas which cuts off a portion of the electrode surface must cause an increase in the resistance to either a direct or an alternating current. The present experiments show that is not the case, and hence one is led to conclude that the phenomena must be of an electrolytic nature depending on the effects of over-voltage and transfer resistance at the electrode surface.

The explanation of the decrease in resistance with flow observed with low values of the applied electromotive force is simple. In this case the transfer resistance at the electrode surface is diminished by

Fig. 2.

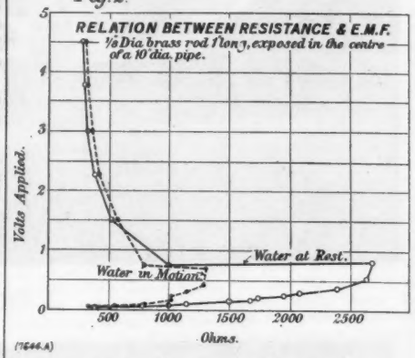
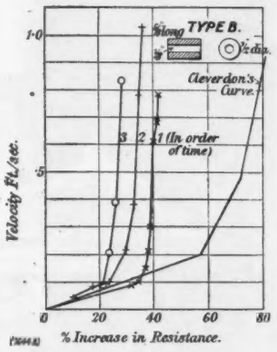


Fig. 3. RESULTS FOR A TYPE B ELECTRODE.



the motion of the water. Roughly it may be said that the moving water removes the hydrogen molecules once they have parted with their charge and so leaves the way open to more ions.

In other work* it has been found that transfer resistance becomes unimportant when the current density on the electrode surface attains any considerable value. Hence in the case of the "higher" e.m.f.'s transfer resistance cannot be expected to play any part in the observed phenomena.

No explanation can be given of why the resistance increases with flow at the higher e.m.f.'s. However, it is possible that an explanation may soon be forthcoming as a result of researches in physical chemistry.

An experiment recently described by J. A. N. Friend† shows a phenomenon similar to that under discussion. Measurements of the potential difference between iron and platinum plates immersed in various electrolytes were made with the liquid at rest and in motion. It was found that slight movement of the electrolyte caused the potential difference to increase, but that a maximum was soon reached, after which further increase in the velocity of the electrolyte caused the potential difference to fall to an almost constant value, which was uninfluenced by the application of higher velocities.

Conclusions.—The results of these experiments show that although, under the particular conditions chosen, the change in resistance of a cathode, immersed in water, depends on the velocity of motion of the water, the relation between them is too variable to allow of the change in resistance being taken as a measure of the velocity.

At the same time it must be remembered that the present series of experiments were wholly empirical. It appears that the phenomena of over-voltage and contact resistance are now being studied by physical chemists, and in the light of their work it may soon be possible to give a satisfactory explanation of the results here obtained. When the principles underlying the phenomena become established, it may be possible to overcome the difficulties which now render the method useless in practice.

* Newberry, "The Resistance of an Electrolytic Cell," Trans. Faraday Soc., 1919.

† "A Colloidal Theory of Corrosion and Passivity of Iron and of the Oxidation of Ferrous Salts." Journ. Chem. Soc., vol. cxix, p. 932, June, 1921.

DETERMINATION OF THE FATIGUE-RESISTING CAPACITY OF STEEL UNDER ALTERNATING STRESS.

By T. ROBSON, A.M.Inst.C.E.

ONE of the most valuable properties that a steel, used in important parts of moving machinery, can possess is its capacity to resist fatigue under alternating stresses. It is usual to subject steels used in important parts of machinery and structures to some form of test, and this precaution is very essential in the case of material entering into the construction of railway rolling-stock. The most usual and generally accepted test for finding the quality of a steel is the tensile test, and whilst it is a fairly good guide, it is known that it does not necessarily show all the good or bad properties of a particular steel, and it would be an advantage to the engineer if, in addition to this test, he could subject steels required to withstand alternating stresses to some quick test that would directly measure their capacity to resist these. A great many ingenious machines have been devised for testing materials under alternating stresses, and whilst they have been valuable in research laboratories for finding out underlying principles, they would not be suitable for routine testing, as they require too much attention to keep in proper adjustment, and the time necessary to make a test is far too long for general work.

The simplest machine is the Wohler cantilever type, in which one end of a cylindrical test-piece is held in a rotating chuck, and stressed by the application of a load suspended from a ball bearing fixed at the outer end. The chuck and ball bearing are the only parts that require close attention, and it is easy to see when they are wrong. This machine tests the resistance of materials to stress alternating equally from tension to compression. The fatigue limit is the safe tensile or compressive stress that can be borne indefinitely, and the safe range of stress is double the fatigue limit.

The usual method of making a fatigue test is to test several samples of the material to destruction. The first sample is tested under a high stress and the number of revolutions before fracture noted. The remaining samples are tested under diminishing stresses in a similar manner till a stress is arrived at that can be withstood for 5,000,000 or more revolutions. The results permit of an endurance curve being drawn, and the safe limit predicted, but as it takes a week or more to make the test, this method of finding the fatigue limit is impracticable except in a research laboratory. Fortunately it has been found that certain characteristics make themselves apparent when the fatigue limit under equal and opposite stresses is exceeded, and these may be taken advantage of, and a quick method developed. It is known that differences of temperature are set up when material is strained, and various devices have been brought out to find the fatigue limit by making use of this property, but whilst quick, they are only suitable for the research laboratory on account of the delicate apparatus required. Another method was discovered by Professor R. H. Smith some years ago when making fatigue tests in direct tension and compression on a machine fitted with a special extensiometer. It was found that at a certain point the extensiometer readings were no longer proportional to the stress,

and further experiments showed that this point agreed with the fatigue limit.

At the National Physical Laboratory tests on material in alternating torsion have shown that the angular twist is proportional to the torsional stress up to the fatigue limit, and then increases at a more rapid rate. It has also been found at the National Physical Laboratory that the deflection of the Wohler cantilever test-piece was proportional to the load up to a certain point, which was found to correspond to the fatigue limit as arrived at by the usual method. The application of this principle to the Wohler cantilever type of fatigue-testing machine is of great importance. This machine, on account of its simplicity, is probably the only one that could be generally used in ordinary testing, so with a simple method of measuring the deflection of the test-piece, a fatigue test on a sample of steel could be made in under half an hour in any well-equipped testing department.

It is not easy to find a simple way to measure the deflection of a revolving test-piece. At the National Physical Laboratory it is done by an optical method. A small mirror is mounted on the end of the test-piece with its plane exactly at right angles to the axis. A lamp free to slide along a vertical scale, and a telescope, are mounted about 20 yards in front of the mirror, and the image of the lamp is reflected from the mirror back to the telescope. When a load is applied to the test-piece, the deflection produces an inclination of the mirror, and the lamp is moved on the vertical scale till its image is again visible in the telescope. By plotting the scale readings against the corresponding loads on the test-piece, the point can be found where departure from a straight line occurs. Whilst this is a very ingenious method it is hardly suitable for everyday routine testing, and a simpler method is necessary before fatigue testing can be generally undertaken.

Sir Vincent Raven, chief mechanical engineer of the North-Eastern Railway, has had investigations made in his testing department with a view to finding a simple method, because it was realised that the underlying principle has made it possible to shorten alternating stress testing to such an extent that it could be made general use of in testing important materials subjected to alternating stresses in service, and it is through his courtesy that the arrangement adopted in his testing department is explained.

The machine used is the ordinary Wohler cantilever type. The main spindle and chuck run in ball bearings at a speed of 2,000 r.p.m. The load is applied to the test-piece through a ball bearing clamped on the outer end of it at a position 10 cm. away from the point of maximum stress. It is 1 cm. in diameter at this point, the diameter is increased where it fits in the chuck, the change being effected by a 1-in. radius. It is necessary that the test-pieces should run true. They are ground, and can be set in the chuck so that the outer end runs true to within two thousandths of an inch. The load is applied by means of a calibrated spring giving very open readings, and coupled up to an oil dashpot to eliminate any vibration.

The apparatus for measuring the deflection of the test-piece is shown on Fig. 1. It comprises a light yet stiff lever held in centres mounted on a rigid frame; the lever is partially balanced, the long end of it is held up by a micrometer underneath; by screwing this down the short end is allowed to rise till a hardened steel point on it touches the underside of the test-piece at its free end. As soon as contact is made, the rapidly revolving test-piece transmits vibrations through the lever to the small bent wire shown hanging in the loop at the long end of the lever. It is sensitive to less than a division on the micrometer thimble, and owing to the leverage, one micrometer division corresponds to one five thousandth of an inch deflection at the free end of the test-piece.

There are probably more scientific methods of measurement than this, but it is as near fool-proof as it is possible to make an accurate measuring appliance, and there is nothing cheaper than a simple lever and ordinary shop micrometer.

The simplest arrangement is not always the first thought of, and the description of an alternative device which was first used may be of interest, and it is shown on Fig. 2. It consists of a chamber full of mercury, the bottom end of which is closed by a flexible diaphragm. A mushroom-headed plunger bears against the underside of this, the stalk of the plunger passes down through a guide, and the end rests on the bearing at the end of the test-piece. The chamber is mounted on a suitable stand resting on a rigid frame. The top of the chamber terminates in a fine bore glass tube in which the mercury is visible, it is fitted with a reader which can be set level with the top of the mercury column. A micrometer head reading to one thousandth of an inch on the thimble is fitted into the side of the chamber, and the spindle passes into the interior. As the test-piece deflects due to the application of a load, the mushroom-headed plunger follows it, and the mercury column falls in the glass tube. By screwing in the micrometer spindle the mercury is brought back to its original height, the divisions on the micrometer being a measure of the deflection of the test-piece. Owing to the difference in area between the plunger and the micrometer spindle, the readings of the latter are rendered 17 times more sensitive, or, in other words, the deflection of the test-piece is measured to one seventeen-thousandth of an inch. This apparatus gave perfectly steady readings with the test-piece running at 2,000 r.p.m., but the lever arrangement is used in preference, as it is more simple and robust.

On Figs. 3 and 4, the results of tests on samples of mild and high-tensile carbon steels are shown. The departure from the straight line is clearly indicated in each case. From experiments made up to the present there does not appear to be any close relationship between the safe fatigue limit and any other physical property. It follows the ultimate tensile strength fairly well, but mild steels have a relatively higher fatigue limit than harder ones, a condition which shows the inadvisability of basing factors of safety solely on ultimate strength, as is frequently done at present.

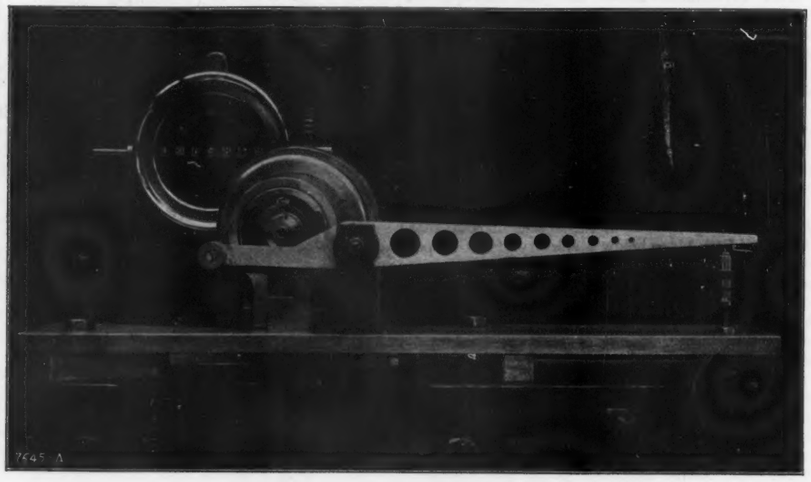


FIG. 1.

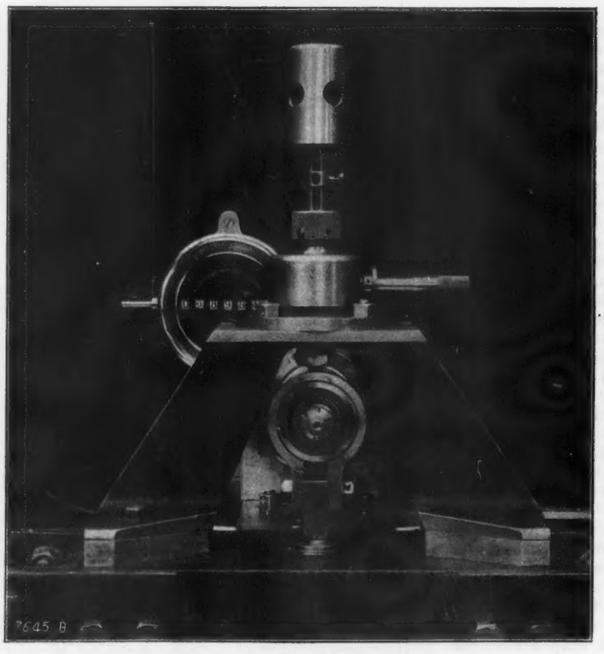
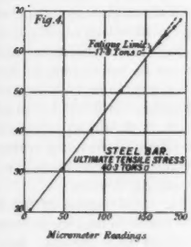


FIG. 2.



NATIONAL UNION OF SCIENTIFIC WORKERS.—The annual meeting of this union was held at Caxton Hall, Westminster, on Saturday, the 13th inst., at 2.30 p.m., under the chairmanship of the retiring president, Dr. A. A. Griffith, who delivered an address on "The Support and Utilisation of Science." In the evening the annual dinner was held at the Florence Restaurant, Rupert-street, W. 1. The chair being taken by the new President, Dame Helen Gwynne-Vaughan.

LARGE SYKES GEAR GENERATORS.

THE Sykes gear generators of the Power Plant Company, of West Drayton, Middlesex, are familiar to our readers, in the smaller sizes, from the descriptions of these machines given on previous occasions in these columns.* We are now able to give in our two-page Plate with this week's issue, drawings of a very much larger type of machine on the same principle, while the illustrations on page 78 show reproductions of photographs of one of these machines in the Power Plant Company's shops, where it has been constantly at work for over twelve months.

The machines with which we are now concerned are of two models, both capable of cutting wheels up to 15 ft. in diameter, while the patterns previously described dealt with wheels up to 53 in. in diameter, so that the difference is considerable, and a comparison of the drawings we now give with those previously reproduced, will reveal many modifications due to considerations of the weight and size of the work handled. The machines now under notice are designed to cut wheels and pinions up to 54 in. wide; the maximum pitch for which they are made is 1¼ D.P. By fitting, additional cutter brackets pitches up to 4½ in. may be cut. The only difference between the two models to be described is in the size of the dividing wheel, which in one case is 10 ft. in diameter, and in the other 12 ft. Apart from this, the general description which follows is applicable to both. A modified pattern of the latter machine is under construction designed for cutting wheels and pinions up to 73 in. face width.

The first difference to be noted between the large and the smaller-sized Sykes generators is that in the former, the work, owing to the much larger weights to be dealt with, is carried in a fixed headstock, and the cutters are mounted on a movable saddle, whereas in the smaller patterns the headstock is movable, and the cutting mechanism on a fixed part of the machine framing. Due also to the variety of face widths which the new machine can accommodate a large range of speeds for the crank drive is necessary; for this purpose an eight-speed change gear-box has been introduced, whereas three or four speeds sufficed formerly. Another change is in the provision made for running the main work spindle quickly for truing and setting up. In the machine we are now describing, a separate motor drive is introduced for this. In the smaller machines it was found sufficient to revolve the spindle and dividing wheel by hand.

The form of the cutters in all the Sykes generators is the same. They take the form of pinions, and in operation are given three distinct motions, which, in effect, make them each represent a single helical pinion in gearing contact with a wheel—the latter being represented by the work, or blank being cut. One of the three motions consists of a slow revolution of the cutter in unison with the wheel being cut, this constituting the tooth profile generating action. A second motion consists of reciprocating the cutter across the face of the work, while the third consists of a twisting motion in unison, by means of helical guides, with the reciprocating movement.

Referring now more particularly to Figs. 1, 2 and 3, on Plate V, a large diameter wheel is shown being cut, in Fig. 2. The work is mounted on a mandrel which is supported between the face plate and main spindle, and an outer bearing. The work is further supported and driven by dogs attached to the face-plate, the latter being in turn secured to the main spindle. The spindle is driven by the large dividing wheel shown enclosed, to the right, in Fig. 3. This dividing wheel is operated by a vertical worm from a drive to which we may as well refer at once. The main drive is from a 15-h.p. motor, shown in the bottom left-hand corner of the plan, Fig. 2. This drive is transmitted through the eight-speed gear-box to a shaft *a*, and also through gears to a second shaft *b*. The latter serves two motions, one of which is to drive, through bevels, and change gears *c*, an oblique shaft clearly seen in the plan, which, by means of other bevels and the vertical worm drive above referred to, secures the necessary revolution of the large dividing wheel. The second motion derived from the shaft *b* will be referred to later.

The cutters *d* and d_1, are, as in earlier machines, mounted on hollow spindles supported in two brackets. The brackets are carried by a long reciprocating slide, on which their position can be adjusted by means of the screw, shown dotted in the plan, according to the width of the face to be cut. The cutter spindles are rigidly connected with helical guides, which are essentially similar to those of the machine we described and illustrated in vol. cxi of ENGINEERING. The helical guides work too and fro' in housings, having corresponding fixed helical guides, so that as the cutter brackets are reciprocated across the face of the work by the operation of the slide to which they are fixed, the cutters are given a helical movement forward and reversed, by means of these guides and housings. The helical guides are very well shown in Figs. 8, 9 and 10 on page 78. The cutter *d*, Fig. 2, it may be mentioned, is integral with the helical guide nearest to it, while the spindle of d_1 is carried through the hollow spindle of d_1, to the helical guide furthest away. The cutter spindle brackets have slanting bases, as previously described, and a small movement of the brackets on these faces, positively controlled, gives the necessary relief for the cutter on the return stroke. The positive control is obtained by the action of a plate cam at the back of the crank drive, Figs. 1, 10 and 11. The slow revolution of the cutters, in unison with the revolution of the work is secured by the housings of the fixed helical guides being arranged to revolve as part of the indexing worm gears, which are designed in a manner very similar to those of the preceding machine. This is the second movement derived from the shaft *b*. The indexing gear is well shown in Figs. 8 and 9, page 78.

The whole of the cutter gear, including the cutters, brackets, reciprocating slide and indexing worm wheels, &c., is carried by a large saddle which is movable on ways along the bed of the machine. On the near, or control side of the machine the saddle is carried by double ways arranged in two tiers; with this arrangement a more compact drive was obtainable. The saddle is guided chiefly on the upper tier of the near ways of the bed. It will be seen from Fig. 2 and Fig. 11 that at this part the saddle is made of a good length. The fair ways, also, though narrow are comparatively long, and taper wedges are provided as shown, for adjustment. The saddle can be traversed quickly by means of a 4-h.p. motor driving, through a worm gear, a large screw passing through a nut in the saddle. This is clearly shown in Fig. 2. In addition a slow hand movement is provided through the nut, and a small worm, and shafts and bevels, to the micrometer hand wheel placed close to the indexing wheels. This hand wheel, through the small worm at the end of the second bevel shaft, causes the saddle nut to revolve, the large screw then remaining stationary. For the fast saddle movement, therefore, the screw is revolved in the fixed nut, while for the slow the nut is revolved on the fixed screw. The micrometer on the hand wheel is graduated to 0·0001 in.

Reverting now to the main drive from the 15-h.p. motor through the eight-speed gear-box to the splined shaft *a*, the main drive to the reciprocating slide is through a sliding pinion on *a* and a large enclosed spur, to the disc crank which will be easily recognised. The crank-pin on this disc is fitted in slides and can be screwed towards and from the centre, as will be evident from the drawings and views of the machine, thus giving the necessary adjustment for the length of the movement to suit the work in hand. Between the main gear-box and the shaft *b* is a second, two-speed, gear-box, giving fine and coarse feed for both the indexing of the cutters and the movement of the dividing wheel. This change of speed is arranged through a positive dog clutch and levers to be seen in Fig. 2, being operated by two solenoids on the right-hand end of the main gear-box. These solenoids are controlled by a tumbler switch on the operating platform. On the shaft *b* a spring-controlled friction coupling is arranged so that in the event of any accident occurring to the driven mechanism, slip is provided as a safeguard against damage to other parts. The change wheels *c* serve to vary the ratio of the revolutions of the cutter to those of the work. The main dividing and the cutter indexing wheels, and other gearing in the system are proportioned so that the driver change wheel in the gears *c* represents the number of teeth in the cutter, while the driven change wheel represents the number of teeth to be cut on the work.

The outer support for the mandrel takes the form of a bracket bearing carried by a heavy saddle which can be traversed on its base, in a direction parallel with the axis of the main spindle. This movement is obtained by means of the usual screw and nut, and the hand wheel shown in the illustrations. The bearing bracket is detachable and is arranged so as to be quickly interchanged with others of various sizes. It can be lifted away with the work and mandrel, or mounted on the mandrel and slipped into position after the work and face plate are mounted on the main headstock. In the case of large and heavy wheels, the mandrel, face plate and work are usually most conveniently assembled on the shop floor while another wheel is being cut in the machine. The whole is then lifted and put into the machine, and to secure it to the machine all that is required is to put into position and tighten up eight bolts holding the back flange of the face plate up to the flange of the main spindle. It may be mentioned that the 9-ft. ring shown being cut on the machine in Fig. 8, was mounted on the face plate in the horizontal position in this way, before being put on the machine. The teeth on this ring are being cut to 2 D.P.

Owing to the size of these machines it has been necessary to ensure by special means the accessibility of all essential controls. With this object the control of the main magnetic clutch, of the saddle traversing motor, and of the fast and slow feed clutches, are all brought to an operating platform shown in Figs. 1 and 8. In other views this platform has been removed for the sake of clearness. The three-tumbler switches are arranged close together above the indexing wheels. Two are two-way switches, while one is a one-way switch. The latter operates the magnetic clutch between the 15-h.p. motor and the gear-box. One of the two-way switches controls through an automatic starter the reversible motor working the main saddle screw which can be run in either direction. The operation of the third switch causes one or other of the two solenoids referred to above, to be energised, and results in the clutching in of the fast or slow gears for the drive of the indexing and dividing gears. Thus, after the work has been set and the main motor started, all control is from the platform. It will be noted, further, that the hand wheel for the hand movement of the saddle is also conveniently close to the same station.

The machines are designed to use standard cutters of 8-in pitch circle diameter and 30 deg. spiral angle. They can, however, use cutters up to 12 in. diameter without modification, or can be easily modified for the use of still larger cutters. They can be employed for cutting straight teeth by replacing the helical guides by straight guides, a change which can be easily accomplished. All spur gearing in the machines is double helical with the exception of the change gears. Details of the main gear-box are shown in Figs. 4 to 7. The eight speeds are obtained by means of two levers shown in Fig. 11, &c., of which the smaller is provided with a gate change giving four positions. In the top of the box are two selector rods working forks which operate two double clutches. In two of the gates the hand lever works one of the selector rods and when in either of the other two gates the other selector rod is operated, giving four changes. These are combined by means of the larger lever with two changes by means of a double clutch on the third shaft of the box.

The machine illustrated in Figs. 8 to 11, has been constantly at work and has cut a number of very high-speed gears. In one set produced the exceptionally high speed of 11,800 ft. per minute was adopted in connection with the transmission of 1,250 kw. This gear was run at 7 per cent. over speed, and is reported as practically silent and entirely free from vibration, which is good testimony to the accuracy of the work turned out. In contrast with this a number of rolling-mill pinions have been cut of 1¼ D.P. in high carbon forged steel. The smallest pitch so far cut on the machine is 8 D.P. It may be mentioned that when the first machine of this size was finished it was immediately put to work on large turbine wheels and kept running for five days and five nights without being stopped.

Amongst the first turbine gears produced on this machine were the Turbine reduction gears for Nuneaton Corporation Electricity works. These were for 1,000 kw. with speeds of 7,500 to 750 r.p.m. and were connected to turbine by Messrs. Escher, Wyss and Cie, Zurich, and generator by the General Electric Company, Witton.

We may mention in conclusion that Messrs. Schneider and Cie, Paris and Le Crusot, have acquired the French, and The Farrell Foundry and Machine Company, of Ansonia, Connecticut and Buffalo, New York, have acquired the American and Canadian rights in the Sykes patents.

* ENGINEERING, Vol. cii, page 34; vol. cx, page 364, and vol. cxi, page 520.

WOOD REFUSE POWER PLANT.

IN this country many old established firms find themselves handicapped with plant now behind the times in view of modern engineering developments. It is a much more difficult matter to face renovation than it is to start fresh works, and a decision must be based on the overall effect of any transformation on the firm's financial position. One of the older firms which has recently had this matter under consideration is that of Messrs. H. Newsum, Sons and Co., Limited, British and foreign timber merchants, who own extensive mills at Gainsborough, Lincoln and Sheffield. As a result of their investigation this firm decided to replace their old power plant at their Gainsborough works with a modern one. This installation has recently been completed and uses as its sole fuel the sawdust and wood waste obtained from the works. The new plant was designed and carried out under the supervision of Messrs. Horace Boot and Partners, 7, Victoria-street, S.W.1, and it is illustrated in Figs. 1-3, page 70, while the views, Figs. 4 and 5, page 71, show two of the shops from which the waste wood fuel is derived.

The power plant consists of two Babcock and Wilcox boilers set in battery with specially enlarged furnaces for burning wood fuel, and mechanical stokers of the Gordon Allison type for feeding in wood chips,

WOOD REFUSE POWER PLANT.

MESSRS. HORACE BOOT AND PARTNERS, ENGINEERS, WESTMINSTER.

Fig. 1. SECTION THRO' A.A.

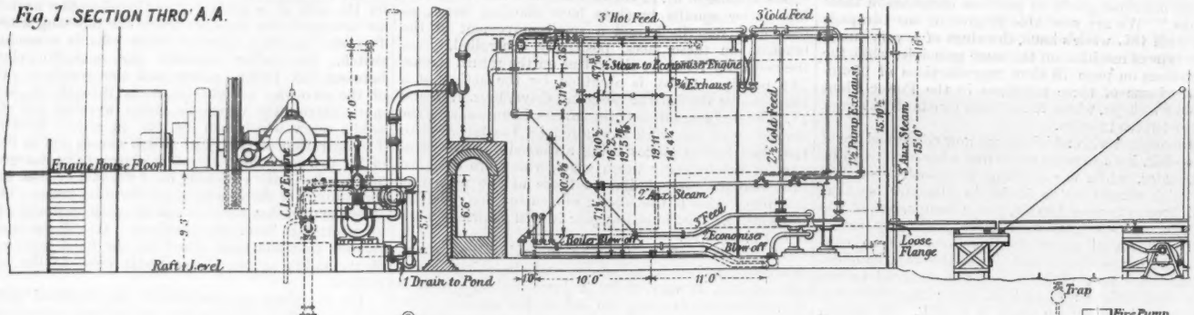


Fig. 2. PLAN

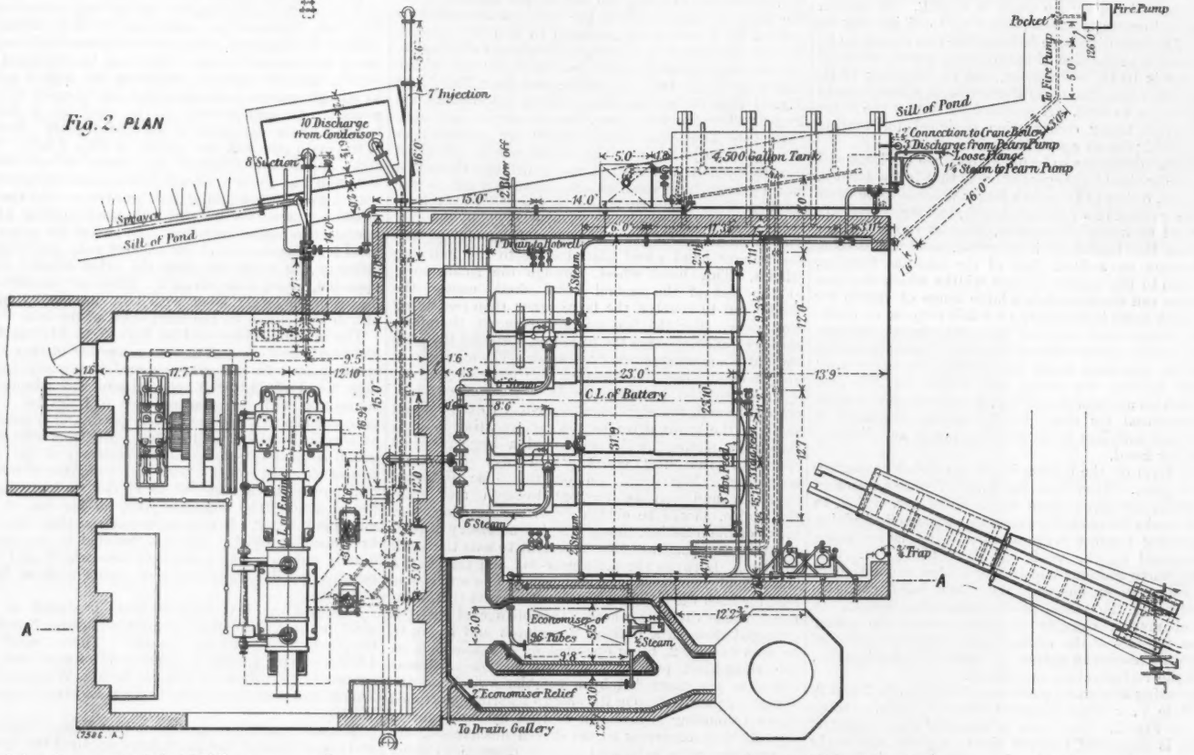
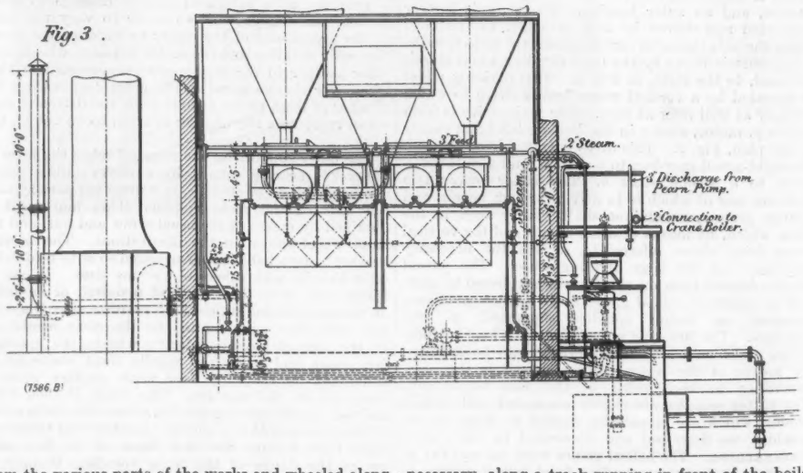


Fig. 3.



supplying steam generated at 150 lb. pressure and superheated to 550 deg. F. to a 550 brake horse-power single cylinder uniflow engine made by Messrs. Robey and Co., Limited, Lincoln. Mounted directly on the crankshaft of the engine is the armature of a 360 kw. 230 d.c. volt generator by the English Electric Company, Limited. Power is distributed to various distribution boards about the works by means of lead-covered and armoured cables laid direct in the ground.

The only available site at the works for the power station was near a cooling pond, but the ground being treacherous, owing to the close proximity of the River Trent, piles about 44 ft. long were used in the foundations. The piles under the boiler house are lagged with asbestos for the first 3 ft. The site of the chimney foundations was heavily piled. A concrete raft, of sufficient area to accommodate the boiler house, economiser chamber and engine room, was built on the piles, while a separate raft was made for the chimney foundations. The rafts were designed so that the top was 1 ft. above ground level; this was done to ensure that the flues would be free from water in the event of a flood. The buildings are constructed of red brick throughout.

The sawdust and chips are collected from the various machines by means of a pneumatic removal plant by the Sturtevant Engineering Company, Limited. Two typical views of the suctions from the machines are given in Figs. 4 and 5. The material collected is discharged into cyclone hoppers situated on the boiler house roof in front of the boilers. These hoppers discharge their contents partly into the stoker hoppers and partly on to the boiler house floor. Small blocks of timber, logs and odd pieces are collected on trucks from the various parts of the works and wheeled along an 18-in. gauge track to an opening which is nearly opposite the boiler house. As the mill floor level is some 7 ft. from the ground level it was necessary to construct a bridge to carry these trucks along to the power house. This bridge is designed to swing back in order to allow the works' cranes to pass, when necessary, along a track running in front of the boiler house. This arrangement is shown in Figs. 1 and 2. The contents of the trucks are deposited on the floor near the boiler fronts and fed into the boilers by hand together with the shavings that cannot be handled by the mechanical stokers.

The grate area of each boiler is 68 sq. ft. and each

WOOD REFUSE POWER PLANT.

MESSRS. HORACE BOOT AND PARTNERS, ENGINEERS, WESTMINSTER.

FIG. 4.

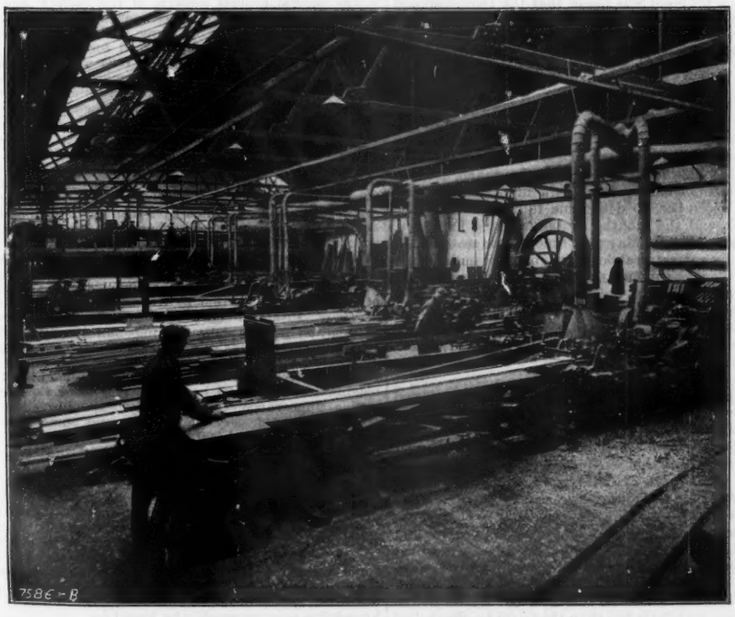


FIG. 5.

boiler is rated to evaporate 10,000 lb. of water from feed water at 212 deg. F. when burning wood fuel only, no coal being required. Provision is made on the boilers for a supply of saturated steam for the auxiliaries, fire pumps and work such as that done in the bending shops, &c. The feed water is obtained from the cooling pond which has a superficial area of 13,386 sq. ft. and an average depth of 6 ft. Water is pumped from the Trent once daily during the dinner hour. The feed water is pumped up to a storage tank of 4,500 gallons capacity situated on top of the staging at the side of the boiler house. A water level indicator is fitted in the boiler house for the guidance of the fireman who can control the pump. The water flows from the storage tank by gravity to a Lassen and Hjort softener of 2,000 gallons capacity and thence to a 500-gallon hot well, from which the feed pump draws, provision being made for the pump to draw direct from the main tank should the softener be out of action.

A 96 tube economiser from the old boiler plant was removed and reset in the main flue, adequate bye-pass flue being provided. The temperature of the feed water at the inlet to the economiser is about 118 deg. F. and that at the exit 200 deg. F. The new chimney is 150 ft. high from the flue level, the first 20 ft. being lined with firebrick. It has an internal diameter of 5 ft. 6 in. The flues and the third combustion chambers of the boilers are also lined with firebrick.

The uniflow engine has a cylinder diameter of 29 in., a stroke of 33 in. and runs at 140 r.p.m. It is fitted with a jet condenser. Messrs. Robey's type of uniflow engine has been so fully described in these columns* that there is little left to say regarding it. The admission valve gear is of the positive drop valve type actuated by cam levers operated from eccentrics mounted on a lay shaft driven by cut skew gearing from the crank shaft. The eccentrics are under the control of a governor of the centrifugal and inertia type, which regulates the position of the eccentrics to give the required cut off to suit the load at a uniform speed. The speed of the engine can be altered whilst running.

The jet condenser is fitted with an air pump of the horizontal double acting type driven from a crank at the end of the crankshaft by means of a connecting rod and a bell crank rocking lever and rod.

The engine room floor being some 10 ft. 3 in. above ground level, practically all the piping in connection with the engine and condenser is under the floor. The injection water is obtained from the pond nearby. The injection pipe leads to the condenser placed below the centre of the main engine cylinder. The mixture of exhaust steam and water passes into a tank made of sheet piling situated at the side of the pond. The water is delivered from this tank to a spray cooler and also when required to the main storage tank, by means of an electrically driven centrifugal pump. The temperature of the water in the tank is usually about 75 deg. F. The capacity of the cooler is 30,000 gallons per hour, and with the pressure at the nozzles equivalent to a head of 20 ft. a reduction in temperature from 106 deg. F. to 80 deg. F. is obtained with a humidity of 70 per cent. The loss of water by evaporation is about 80 per cent. of the steam dealt with by the condenser.

The generator, which, as stated, is carried on an extension of the crank shaft, is shunt wound. The switchboard consists of ten panels including three spares. Five panels control the various power circuits with distribution boards in the works. Each panel is fitted with an overload breaker, single pole switch, fuse, kilowatt-hour-meter and ammeter. The supply for the stoker motor and centrifugal pump motor is taken direct off the bus bars. As considerable trouble is experienced in the district with lead-covered cables buried direct in the ground due to the rapid deterioration of the lead, precautions were taken to prevent such trouble arising in this instance. Several schemes were investigated, and it was finally decided to adopt a paper-insulated lead-covered twin cable specially armoured, the armouring being served both inside and outside with jute bitumen compound, and hessian tape, the cable being laid direct in the ground.

It may be stated that before it was decided to adopt this type of steam plant the possibility of installing gas engines to run on gas from producers burning wood refuse fuel was considered. The advantages, however, were finally decided to lie with a steam-driven plant. Up to the present there has been no cause to regret this decision, the consumption of fuel being so low that a considerable quantity of the works waste is unconsumed, the boilers running mainly on sawdust and chips without using the logs.

THE ERECTION OF THE BELLE ISLE BRIDGE.—An interesting method has been adopted of placing in position the steel work of a large steel and concrete arch bridge being erected at Belle Isle over the Detroit River, in the United States. The steelwork for the arches was erected on shore and floated into place. Instead, however, of dealing with complete arches, the sections dealt with consisted of two contiguous halves of adjacent spans. With temporary steelwork these formed double cantilever units, and when completed ashore, a flooded pontoon carrying falsework was floated into an improved dock under each arm. The pontoons were then pumped out and carrying the unit, were towed out to the pier prepared in the river, where, on flooding the pontoons again, it was possible to deposit the unit in position on the pier. The work is being done by the Wisconsin Bridge and Iron Company.

NORTON AND GREGORY ANNUAL SCHOLARSHIPS IN ENGINEERING.—Messrs. Norton and Gregory, Limited, offer two engineering scholarships to be competed for annually, one value 100*l.* per annum, and one value 50*l.* per annum, tenable for three years at any University in the United Kingdom or British Dominions approved by the committee. Candidates must have reached the age of 17 but not the age of 19 on March 1 in the year of examination, be domiciled in the United Kingdom, and undertake to pursue a three years' course in engineering with a view to following it as a profession. Qualifying examinations are to be held at different centres, and the examiners are to select of limited number of candidates for recommendation to the committee, who will then make their final selections chiefly by means of a further oral examination to be held in London. The examination for the 1923 scholarships will be held in March at a date to be fixed later, and all application forms must reach the committee not later than February 1, 1923. Application forms may be obtained from the Secretary, Scholarships Committee, Messrs. Norton and Gregory, Limited, 1 and 2, Castle-lane, Westminster, London, S.W.1.

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* See vol. cx, pages 104 and 162.

INDUSTRIAL NOTES.

Serious difficulties appear to be pending in the building trades throughout the country. Conferences have been held at which the employers have put forward proposals for an immediate reduction of 20 per cent. on existing rates both for time and piece-work; an extension of the present working week; and the introduction by degrees of payment by results on a bonus system. After one of these conferences, Mr. R. Coppock, secretary of the National Federation of Building Operatives, stated that the employers had asked for the extension of the working week to 47 hours for eight months of the year, 44 hours for two months and 41½ hours for the remaining two months. He added that the men were unable to agree to any extension of the working week, further stating that the proportion of the reduction might be a negotiable point. He also said that "the operatives maintain that in consequence of the fact that there was a departure from the sliding scale to meet the position of June 1 last year, and that the figures of the cost of living showed no decrease, but rather an increase, they were entitled to claim stability of wages and hours for a period of twelve months. The employers were unable to concede this or discuss the situation further and a complete deadlock ensued. It is understood that the question of payment by results was eventually dropped. A further conference has been announced. Complaint is heard, on the other hand, that the wage of building trade operatives is 1*s.* 8*d.* per hour, as against 1*s.* 3½*d.* for a skilled engineer.

It will be remembered that a dispute on hours and wages occurred in the building trades last spring, when a settlement was reached by which wages were reduced by 2*d.* per hour in April and by a further 2*d.* in June. At that time the employers urged an extension of the working hours, but a compromise was reached, and further consideration of the extension of the working week was deferred until the conferences above referred to. The employers' argument is to the effect that a longer working week in the summer is necessary if the building trade is to revive. They add that the men in 1914 worked 10 hours a day for a wage of 9½*d.* per hour, and point out that fewer bricks are laid to-day, hours are shorter and wages are 1*s.* 8*d.* per hour.

In the report for the present month issued by the United Society of Boiler Makers and Iron and Steel Shipbuilders, the general secretary places the question of unemployment and its relief in an absolutely wrong light. He says: "When we ask our Premier and those who support him in power why they prefer to keep about one-third of the nation living or half-living on doles and in idleness, rather than employ them on useful work," the answer is that "it would interfere with private enterprise." We feel confident this is not a matter of preference on the part of the Premier. A proof of this is afforded by his speech last Tuesday to a deputation from the General Council of the Trades Union Congress on the unemployment problem. It is most certainly not a matter of preference on the part of the taxpayers. To see, for example, a former master builder, now, as a matter of course, regularly in receipt of the dole, whilst in former years he has rarely been sober for any length of time, his business and his capacity having gradually gone to ruin in consequence, is an instance, among very many no doubt, which, to put it as mildly as possible, gives the working and tax-paying portion of the community most furiously to think. Nevertheless, there are no doubt in the number of unemployed a great many deserving cases. But the system of relief has been started on a wrong basis and is being badly worked. Mr. A. Senior, a director of Messrs. George Senior and Sons, produced at a recent inquiry a list showing that some married men were asking to leave their works in Sheffield in order to get as much in unemployment relief as by working.

At the inquiry above referred to, Mr. L. Munns, secretary of Messrs. Cammell, Laird and Co., Limited, Sheffield, stated that in the case of steel tyres the cost per ton due to the rates had risen from 3*s.* 1½*d.* in 1914 to 2*l.* 0*s.* 11½*d.* in 1922, equal to an increase of 1,210·7 per cent.; the guardians' call for 1914 was 6*d.* per ton, and for 1922 it was 18*s.* 11*d.*, or an increase of 3,683 per cent. In the case of steel axles the cost per ton due to the rates had risen from 2*s.* 7½*d.* to 2*l.* 19*s.* 3½*d.*, or an increase of 2,158·7 per cent.; the guardians' call had risen from 5½*d.* per ton to 1*l.* 7*s.* 5*d.*, equal to an increase of 6,166·7 per cent. There had been proportionate increases in the other specialities of the firm, and also in those of all other firms. To these business statistics we may add that in the case of a private resident in one of the London suburbs, the local rates increased to six times what they were in 1914, but have since been reduced somewhat. All concerned, business firms and private residents, would much "prefer" to see "about one-third of the nation" living on actual earnings.

The question of British *versus* foreign tram rails, says *The Yorkshire Post*, has been before the Hull City Corporation in various forms. The trouble began last October, when the Tramways Committee, after going through the tenders of several British and foreign firms, were so anxious to deal with the former that it was decided to ask a Sheffield firm to reduce their price to a figure near that of a German competitor, so that their offer might be accepted. When this came before the City Council for confirmation it was, after a lengthy discussion, referred back to the committee for re-consideration, with the result that the subsequent voting in committee was equal, and there was no further progress. A fresh start was made by the committee in recommending that tenders be invited from four British firms to be named by the engineer; but this was turned down by the City Council, and after another debate it was agreed that tenders were to be invited unconditionally by advertisement.

The following tenders were opened in committee on New Year's Day:—

	Rails 1,000 Tons.	Fish Plates 30 Tons.	Sole Plates 14½ Tons.	Total.
	£	£ *s.*	£ *s.*	£
Anglo-Belgian Improvements Corporation, Brussels	8,925	311 5	(No price)	9,236
Cargo Fleet Iron Co., Ltd., Middlesbrough	14,000	420 0	203 0	14,623
Steel, Peech and Tozer, Sheffield ..	13,500	540 0	290 0	14,330
Equipment and Engineering Co., London	9,150	274 10	188 10	9,613
	(Manufactured in Germany.)			

After another discussion the committee recommended the acceptance of the tender of the Anglo-Belgian firm as being the lowest. When the matter came up for final decision at a meeting of the Hull Corporation recently, a proposal was made that the tender should go to the Sheffield firm; but only three voted for this and the acceptance of the Belgian tender was confirmed. This shows that Hull does not wish to be saddled with the expense of caring for Sheffield unemployed.

The National Wages Board for the coal industry, representing coal owners and miners met in London a few days ago; Mr. Herbert Smith occupied the chair, the vice-chairman being Mr. Evan Williams. It was agreed that the following periods be taken for the ascertainment of wages, namely, the months of November and December, to determine the wages of March and April, and the months of January and February, to determine those of May and June. It is stated that, generally speaking, rates based on November and December figures will mean higher wages in the majority of districts. Formerly, the monthly returns of working results served as a basis for the ascertainments; the Christmas holidays, however, interfered with the December figures and it was decided to bring in those for November also, as above stated.

Writing recently to *The Times*, Lord Weir reviewed the present industrial situation in this country. He stated, among other points, that his firm had been anxious for some time to build a considerable number of new houses near their engineering works. They had allocated the necessary capital, but they had not placed the contracts for the following reasons. If the houses were gone on with, the bricklayers would start working in full view of the engineering workers. They would receive 72*s.* 6*d.* per week for 44 hours' work, whilst the skilled engineering tradesmen would only receive 57*s.* for 47 hours' work. The bricklayer's labourer, carrying mortar, would receive 55*s.* 6*d.* for 44 hours' work, a rate very little less than that paid to the skilled tradesman. The industries which are fighting hardest to bring about a trade revival by adjusting their conditions to suit the economic position, find their efforts to a distinct degree nullified, Lord Weir added, by the attitude of the railways, dock authorities, building trades, municipalities, &c. No one desires, he said, to reduce wages for reduction's sake, but costs must be reduced to revive industry and bring down the cost-of-living figure. No one wants to reduce the standard of living, but an industrial country such as this could not permanently guarantee to any section of its population a specific standard of living. Must the trader and manufacturer, asks Lord Weir, assail the new railway combinations and demand that they make their proportionate contribution towards reduction of the costs of coal, iron, steel, ships and engines? Is it not rather the part of these authorities to recognise, and that speedily, their responsibility in regard to the nation's production? Similarly for other authorities and industries where the adequate contribution has not been made, it is for each to face this issue without loss of time. The cost of production, the cost of living, and re-employment itself depend on a more uniform national effort in regard to this painful but essential process of readjustment.

With further reference to the proposed reduction by 6*s.* 6*d.* per week in the war bonus allotted to the railway shopmen, so as to make the total reduction 16*s.* 6*d.*, equal, therefore, to the reduction applied to the general engineering trades, a conference was held in London last Tuesday, when an agreement could not be arrived at. At the close, the following statement was issued:—

"The conference was represented on the workers' side by the Federation of Engineering and Shipbuilding Trades, the Amalgamated Engineering Union, the Foundry Workers' Union, and the General Workers' Federation. It was pointed out by the workers' representatives that, with the reduction already made and the application of the railway shopmen's award, the present total wages earned by the men would not exceed those payable to the operatives engaged on a similar class of work outside the railway shops. The craft unions also declared that the recent award had resulted in a loss of status to the men and rendered classification extremely difficult. The representatives of the unions also stated that they could not agree to accept any further reduction whatever of the war bonus.

"In reply, the companies' representatives stated they could not accept the figures submitted by the unions, and denied that the effect of recent reductions was so bad as the craft unions had made out. It was eventually agreed to adjourn the conference for three weeks in order that the sub-committee of the companies might have an opportunity of re-examining the position and the figures submitted to the railway managers, as well as of considering the redrafting of the proposed new machinery for negotiating questions affecting the railway shopmen."

ROYAL METEOROLOGICAL SOCIETY.

THE annual general meeting of this society was held on Wednesday, the 17th inst., at 49, Cromwell-road, South Kensington, Dr. C. Chree, F.R.S., President, in the chair. The Report of Council for 1922 was read and adopted and the council for 1923 was duly elected. An outstanding feature of the report was the transference to the society of the property and funds of the British Rainfall Organisation. The society has undertaken to administer the funds and to continue the observations at 62, Camden-square, which were commenced by the late Mr. G. J. Symons in 1859.

The president, Dr. C. Chree, F.R.S., delivered an Address on "*Aurora and Allied Phenomena*," of which the following is an abstract: Brilliant aurora in England seems always accompanied by a magnetic storm and any outstanding magnetic disturbance is accompanied by aurora. Thus presumably they have a common cause, and this is now generally believed to be electrical currents in the upper atmosphere, originated by a discharge of some kind from the sun. Our knowledge of the height of aurora is mainly due to Norwegian scientists. One of these, Professor Carl Störmer, discovered how to photograph aurora. By taking simultaneous photographs from the ends of a long base, and measuring the apparent parallax, he is able to calculate the height. For the lower level of aurora he finds heights in the neighbourhood of 100 km. The height of the highest visible appearance varies greatly. Heights exceeding 300 km. are not very uncommon, and some measurements have exceeded 600 km. As we travel northwards from the South of England aurora and magnetic disturbances both increase, the former at least very rapidly. The auroral frequency in Shetland is supposed to be from 10 to 20 times that in the extreme South of England. There is thus within the British Isles a great variety in the frequency or intensity of aurora and, it is also believed, in the intensity of magnetic disturbance. An observatory provided with magnetographs has recently come into existence in Shetland, and if adequate means are forthcoming for the intensive study of auroral and magnetic phenomena, substantial contributions to knowledge may reasonably be hoped for.

BRIDGE FOR BERGEN, NORWAY.—The Acting British Consul at Bergen reports to the Department of Overseas Trade, that the Municipality of Bergen has organised a competition in connection with the building of a new bridge over Nygaardmstromsen in Bergen.

A NEW UNDERGROUND CONTRACT.—In anticipation of the opening of the new lines now in course of construction a contract has been placed for a 15,000-kw. turbo-alternator for the power station at Lots-road, Chelsea. The turbines will be constructed by Messrs. C. Parsons and Co., Limited, and the alternator itself by Messrs. The Metropolitan-Vickers Electrical Company, Limited. At the same time alterations are to be made at Chelsea to perfect the existing electrical plant. One of the improvements to be effected is the replacing of the cast-iron cylinders of the existing turbines with cylinders of steel which will thereby considerably increase their efficiency. Thus over 100,000*l.* altogether is to be expended on necessary electrical equipment.

RAILWAY ECONOMICS FOR EXTRA-EUROPEAN RAILWAYS.*

By HAROLD STRINGER, B.A., Assoc.M.Inst.C.E.

THE extra-European countries now needing railways may be classed as: (*a*) Sparsely populated by semi-nomadic peoples, and (*b*) thickly populated by more developed races. These classes need different standards of railway construction to meet the probable traffic; and the factors governing these standards are (1) rail-weight, (2) maximum gradient, (3) minimum radius of curvature, and (4) gauge.

(1) *Rail-Weight.*—A correct decision on this point determines the comparative usefulness of the line. The ratio of ton-miles to train-miles increases with rail-weight, and, assuming maintenance and traffic charges to be independent of rail-weight, the locomotive charges only will vary (provided that full loads be carried). The variation of locomotive charges is due solely to fuel consumption, which comprises 50 per cent. of the total charges per train-mile. Thus a 10 per cent. increase in rail-weight gives a like increase in capacity at a 5 per cent. increase in cost. The overhead charges per train-mile to meet the cost of increased rail-weight can be balanced against the decrease in cost per ton-mile when the probable traffic density is estimated. Further, the cost of a generous rail-weight can be met, to some degree, by a reduction in the number of sleepers. Spacing of sleepers can be reduced in due course to cope with increased traffic. Since the cost of sleepers is not proportional to rail-weight, and since rail stiffness increases with the square of the weight, rail-weight is the last item on which to economise. For any line, traversing any but the easiest country, the 40-lb. rail is the minimum.

(2) *Gradients.*—The effect of gradients on coal consumption is proportional to the weight of train hauled. It is possible to estimate the cost of pusher locomotives, and hence the additional cost per train-mile over sections entailing their use. Assuming that the effect of a pusher is to double the available tractive effort, its use will become uneconomical when the additional cost equals the costs per train-mile over the rest of the route, as the trains might as well be split up. High maximum gradients are economically sound, provided that the construction of the line is non-committal in character. In China, on a 600-mile line with two trains per day, the additional cost per train-mile of working 10 miles of 1 in 50 gradient with a pusher is but 1*d.* per train-mile, or less with more traffic. This is estimated to be a saving of 2*d.* per train-mile on the equivalent capital charges required to reduce this gradient to 1 in 100. Chinese practice in double-heading is to allow 30 per cent. additional load. For gradients steeper than 1 in 19, rack railways are a necessity, though undesirable; capital, maintenance and running charges are all higher, and at least two locomotives are required, in addition to siding and other accommodation at each end of the section. Where high maximum gradients are adopted, constructional standards should allow timber or steel trestle bridges which can be dismantled and re-utilised; concrete represents so much buried money.

A table is given showing the coal consumption on various Indian railways. This appears to demonstrate that gradient is without effect on coal consumption for long runs; but the ratio of coal consumption to weight is not constant for similar conditions, and costs per ton-mile are a minimum in the case of those railways in the table which have the largest proportion of level track.

(3) *Curvature.*—A long bogie lead for locomotives on lines of sharp curvature is important, as it prevents derailment and excessive wear. The limiting curvature fixes the maximum rigid wheel-base of locomotives, and hence their tractive power; and various devices to minimise this limitation are considered. The effect of much curvature on lines of light traffic is negligible after settling down has taken place, and the initial maintenance charge properly belongs to the capital account. The lengthening of a line due to much curvature is of no account in sparsely-populated countries where competition does not exist, and its limit is found by formulas which indicate the extent of the country it would pay to investigate. Allowance should be made for an increase in locomotive weights when fixing the maximum curvature, and the ruling gradient should be reduced on curves by an allowance of 0·02 per cent. for each degree of curvature.

(4) *Gauge.*—For comparison of costs of lines of different gauges, lines of similar capacity as regards rail-weight and curvature limits must be taken. The savings in constructional costs for narrow-gauge lines accrue from reduced charges for land, earthwork and permanent way, and from the use of sharp curves; and maintenance is reduced by smaller rail wear on curves, and by less costly sleeper renewals. A table of permanent-way standards for various railways is given. The author shows that the effect of gauge on cross-sectional area should be considered before its effect on land quantities can be estimated. Obviously, on routes of the same traffic capacity as far as curvature limits are concerned, the effect of gauge decreases with the heaviness of earthwork. The importance of savings in earthwork depends on the supply of labour, while land quantities are of importance only in thickly-populated countries.

The savings on permanent way due to narrow gauges are discussed—these result from lighter sleepers or a reduced quantity of ballast. Various standards are compared, and it is concluded that the number of sleepers per mile does not vary appreciably with the gauge. The saving in cubic content of sleepers represents approximately the saving in money. The use of steel sleepers is discussed and is shown to be advantageous provided that the soil is not alkaline, and that sand or gravel is used as ballast. Particular advantages become apparent where the white ant is prevalent and where ballast is expensive. Ballast-thickness under the sleeper ranges from 4 in. for a 40-lb. rail to 10 in. for an 85-lb. rail.

Summarising the savings in quantities for the narrower gauges of the same rail-weight, curvature limits, &c., and assuming an average height of bank of 2 ft., the following table is obtained, the 4-ft. 8½-in. gauge being indicated by (A):—

Gauge	Metre or 3 Ft. (B).	2 Ft. (C).	2 Ft. (C).
	per cent.	per cent.	per cent.
Earthwork	15.8 of (A)	31.6 of (A)	18.8 of (B)
Land	10.2 of (A)	25.5 of (A)	17.0 of (B)
Masonry	13.6 of (A)	27.2 of (A)	15.8 of (B)
Timber sleepers ..	33.0 of (A)	55.0 of (A)	33.0 of (B)
Steel sleepers	35 to 37.5 of (A)	63 to 66 of (A)	43 to 45.5 of (B)
Ballast	30.7 of (A)	46.2 of (A)	22.2 of (B)

These percentage results approximate to the savings, in money for each item, and they decrease, naturally with the rail-weight.

Various maintenance figures are discussed in relation to traffic, speed and rainfall, and Chinese practice shows 5·1*d.* per train-mile on the 4-ft. 8½-in. gauge with 12 trains per day, and 3·56*d.* per train-mile on the metre-gauge with 5·3 trains per day.

Choice of gauge is a matter of available capital and the probable expansion of traffic. Mixed gauges soon prove to be objectionable, and every effort should be made to avoid them by a lowering of all constructional standards except, perhaps, rail-weight. In sparsely-populated countries, either the metre or the 3-ft. 6-in. gauge should be the minimum, as these give due facilities for traffic expansion; the rolling-stock can eventually be built of the same capacity as that of the 4-ft. 8½-in. gauge. If a narrower gauge still be adopted through lack of funds, the line should be built with a view to future gauge alteration. In thickly-populated countries, where traffic is assured, the 4-ft. 8½-in. gauge offers the largest margin of traffic-handling capacity. Any narrower gauge should be confined to the hill country and should not be less than 3 ft. 6 in. Where even this would involve too great expense, the author is of opinion that a preferable alternative would be the construction of roads and the use of motor transport. The economy of the steam tractor is particularly evident.

Comparative costs per train-mile over railways of various gauges are given, showing lower figures for narrow gauges; but the cost per ton-mile on the metre-gauge in India is almost double that on the 5-ft. 6-in. gauge. Costs per passenger-mile in India are practically the same for the metre and 5-ft. 6-in. gauges. The author considers it may safely be said that 30 per cent. to 40 per cent. of the expenditure on such lines is independent of the traffic.

For purposes of location, the author favours the making of a fairly detailed survey by tacheometer, which cuts down the expensive staff of white men and is quicker than the older method of traverse. Location alone has been carried out in the bush country of tropical South Africa for 64*l.* per mile. In China 4 miles per day can be located at a cost of 2*l.* per mile in the Great Plain, and in the south, where the country is more difficult, for 70*l.* per mile.

The author concludes by drawing attention to variations in formation and culvert "standards," for which there is no obvious reason.

* Abstract of a paper to be read before the Institution of Civil Engineers, on Tuesday, January 23.

REINFORCED CONCRETE ON THE CHINESE RAILWAYS.*

By HAROLD STRINGER, B.A., Assoc.M.Inst.C.E.

THE increased cost of timber, and its short life, have compelled the adoption of reinforced concrete as a substitute. The usual reinforcement consists of scrap, such as rails, boiler tubes, bars, corrugated iron, or telegraph wire. A few experimental beams, with old-rail reinforcement, have been tested, and some adhesion experiments have been carried out. These are described, being of interest where makeshifts are an economy, if not a necessity.

Rail-Reinforced Beams.—Rail reinforcement has a large perimeter, and the change in tension per linear inch transmitted to the concrete is high, amounting to 1,360 lb. per square inch run with the 60-lb. rail in use on the Chinese railways, and 75 lb. per square inch bond stress. The maximum allowable shear in a beam of rectangular cross-section, and hence the maximum reaction at the supports, is about $\frac{7}{8}$ D × 1,360 lb., where D is the depth measured from the upper surface of the beam to the bottom of the reinforcemnet (the overall depth is D + 2 in.). It is this relation which determines the maximum loading of a beam—particularly of a short beam—and not the resistance moment. In the case of a beam 2 ft. wide, 1 ft. 6 in. deep, reinforced with one 60-lb. rail, the maximum allowable reaction is 7 tons, corresponding with 14 tons distributed load. The maximum resistance-moment determined by the concrete is 22·2 ft.-tons, thus the critical span is 12·7 ft. Also, since shear in the concrete transmits the difference in tension in the reinforcement to the compression side of the beam, and since shear stress in the concrete is assumed to be limited to 40 lb. per square inch, the width of the beam = $\frac{1 \frac{3}{4} \frac{0}{0}}{40}$ = 34 in. at the supports per rail of reinforcement, and this relation governs the spacing of such reinforcement.

A table is given showing results for resistance-moment and position of neutral axis for rail-reinforced beams of various cross-sectional dimensions, and the most economical appears to be 5 ft. in width by 1 ft. in depth. Such a beam, 16 ft. in length, was constructed and was tested to destruction, failing by the breaking down of the adhesion under a distributed load of 24·75 tons on a span of 13 ft. 6 in. This indicates a factor of safety of about 3, assuming 600 lb. per square inch and 7·5 tons per square inch maximum working stress for concrete and steel respectively. Two similar beams, 2 ft. wide and 1 ft. 6 in. deep, were tested on a span of 13 ft. 6 in., one being of 1 : 2 : 4 mixture, and the other 1 : 3 : 6. Each withstood an applied bending-moment of 20·5 ft.-tons without fracture. The calculated safe resistance-moment was 22·2 ft.-tons for the first, and 13 ft.-tons for the second, based on a fibre stress in the concrete of 600 lb. and 350 lb. per square inch respectively.

To investigate the effect of a high proportion of reinforcement, a beam 1 ft. 6 in. wide by 1 ft. deep, reinforced with one 60-lb. rail, was tested; this failed by fracture of the reinforcement under an applied bending-moment of 50 ft.-tons, showing a factor of safety of 4·6. In order to investigate this effect further, five 1 : 2 : 4 beams, 5 in. deep by 3 in. wide, were tested on a span of 4 ft. The reinforcement was 3 in. below the top of the beam and was varied in each case, being: One ¾-in. bar; four ⅜-in. bars; one ½-in. bar; four ½-in. bars; and nil. The experiments showed the superiority of the concentrated form of reinforcement, and indicated that 75 lb. per square inch might be safely used as a shear-stress in calculating the spacing of the reinforcement. The formulas (both theoretical and empirical) used by the author gave satisfactory results with only native supervision of the casting of the beams.

Tests to determine the bond-stress of telegraph wire as reinforcement indicated an ultimate value of 203 lb. per square inch, while that of galvanised sheet-iron was only 42 lb. per square inch.

Application of Reinforced Concrete to Bridges, &c.—A table suggesting designs for 12-ft., 20-ft., and 30-ft. spans is given, showing a marked saving in cost in comparison with steel bridges. Further advantages are the elimination of painting, and the provision of an all ballast road. Examples and details of standard bridges are shown. Reinforced concrete has been applied successfully to such small items as signal posts, signal-wire pegs, &c.

Concrete Pipes.—Experiments have been carried out with various 8-in. and 9-in. pipes, 8 ft. long, reinforced with spirals of telegraph wire. These leaked at low pressures. Reinforcement of sheet iron, soldered at the joint, gave better results at less than one-third of the cost of cast-iron pipes. A series of tests of several different patterns of 9-in. piping, 3 ft. 6 in. long, showed that the concrete was strong enough without reinforcement to stand pressures of 40 lb. per square inch, and that reinforcement caused porosity owing to the difficulty of tamping the 2-in. shell in the mould. Culvert pipes, 18 in. diameter with wire reinforcement, and 12 in. diameter without reinforcement, have proved satisfactory, costing each 1*s.* 8*d.* per foot, in 8-ft. lengths at pre-war rates.

* Abstract of a paper to be read before the Institution of Civil Engineers, on Tuesday, January 23.

THE LATE MR. ALFRED HARPER CURTIS.—We regret to have to announce the death, which occurred on the 10th inst., after a very brief illness, of Mr. Alfred Harper Curtis, of the Imperial Mineral Resources Bureau. Mr. Curtis was the second surviving son of the late Mr. Alfred Curtis, Town Clerk of Neath (Glamorgan), and was born in July, 1863. He was articled to Messrs. Taylor and Struve, Neath and Briton Ferry, for three years, from 1881 to 1884, during which time he obtained a medal, prize and certificate in mechanical engineering from the City and Guilds of London Institution, and other science certificates. As a result of evening study he also graduated in 1884 as B.A. first-class, London University. Mr. Curtis then studied for one session at Owens College, Manchester, under Professor Osborne Reynolds. Having obtained a studentship in open competition in 1885, he attended the Royal School of Mines and studied there for two years, obtaining a first-class certificate in mining, including surveying, assaying, &c., and other certificates in science. From 1887, Mr. Curtis visited the Transvaal and the Republic of Honduras, developing, inspecting and reporting upon gold and other mines. A few years later he entered into an arrangement with Messrs. Bewick and Moreing as engineer for British and foreign mining work. He spent long periods on such work in New Zealand and Japan, and while in New Zealand he was a member of council and one of the honorary secretaries of the New Zealand institute of Mining Engineers, to which body he contributed a paper in 1892 on "The Examination and Valuation of Mines." During the war, Mr. Curtis did a considerable amount of work at the Imperial Institute, reporting upon the mineral resources of the British Empire and of foreign countries; he compiled the publication on "Manganese Ores" issued by that Institute. He joined between two and three years ago the Imperial Mineral Resources Bureau, and took a prominent part in the compilation of the statistical and descriptive reports issued by that bureau. Mr. Curtis was a man of wide experience, untiring energy, and was greatly liked by all with whom he came into contact. He had been an associate member of the Institution of Civil Engineers since 1890, and read before that institution in 1892 a paper on "Gold Quartz Reduction," for which he was awarded a Telford premium. He was also a member of the Institution of Mining and Metallurgy.

PORTABLE TESTER FOR GEARING.

WE illustrate on this page a simple and handy device for testing the accuracy of the pitch of gear teeth, and also the truth of the alignment of the pinions and wheels when in place. The tester in question has been devised by Mr. W. van West, of Oost Handelskade 30, Amsterdam, who is an inspector of the North Holland Lloyd. The tester can be used with the gears in place, and in these conditions it is found convenient to measure the axial pitch of the helical teeth, rather than the circumferential. The apparatus consists of a round bar, denoted by A in Figs. 1 and 2, and a straight steel bar. The square bar is fixed in a groove cut parallel to the axis, and serves as a bed, over which the measuring devices can be moved. With the pinion and wheel in true alignment, this square bar will always be parallel with the axes of the wheels when the bar A is placed as indicated in Fig. 2. The bar A is magnetised, and thus fits itself in between the wheels, and is held firmly without risk of distortion. A rod C, which can be clamped by a set-screw, as best seen in Fig. 1, serves to adjust the angular position of the magnetised bar by abutting against the pinion shaft as indicated in Fig. 2. On the square bar a block, B, is arranged to slide. This block carries the two fingers, E and D, clearly shown in Fig. 1. The finger E can be clamped at any desired point of the rod F by the milled head shown, whilst the finger D has a tailpiece which abuts against a dial micrometer as indicated. Both fingers can be rotated around or with their supporting rod, F, which is secured by a clamp, as shown in Fig. 2. An adjustment is provided at H for bringing to zero the indicator of the dial micrometer G. If the whole apparatus is pressed in an axial direction, the ends of both fingers come into contact with the flanks of consecutive teeth, and the reading of the dial micrometer is recorded. A second set of readings is taken after shifting the apparatus one pitch forward, the operation being repeated till a complete record is obtained. Mr. van West states that in the case of a pair of smoothly running marine gears, on which he made measurements as above described, the greatest difference found in the axial pitch was only 0·03 mm., or about $\frac{12}{10,000}$ in.

The device can also be used for testing the teeth of pinions before being put in place. To this end the pinion is laid on a flat surface, as indicated in Fig. 4, and the bar A held between the pinion and an angle-plate, the measurements being made as before. For testing the alignment of gears the apparatus is placed as indicated in Fig. 3, and the bar turned round until one end of the edge of the square bar touches the teeth. A feeler gauge, inserted under the other end, measures the error of alignment.

AUTOMATIC CONTROLLER FOR INDUCTION MOTORS.

SINCE in most cases there can be no question as to the economy and convenience of employing electric motors for driving industrial plant, the decision to adopt electric driving frequently depends upon the matter of reliability. The latter is, of course, of the utmost importance since the loss incurred by machinery standing idle for a few hours, as a result of a breakdown, may easily out-balance the saving due to electrical operation. It is difficult to imagine any more reliable electrical machine than a polyphase-induction motor of the squirrel-cage rotor type, but the starting characteristics of these machines are such that, generally speaking, they can only be employed for small powers. For larger powers, and for those forms of drive in which a good starting torque with a moderate starting current are necessary, induction motors with wound rotors provided with slip rings, to enable a resistance to be inserted in the rotor circuit for starting, may be employed. Such machines themselves are almost equal in simplicity and reliability to the squirrel-cage motor, but the starting gear introduces an additional possibility of breakdown, especially when the machine has to be started, stopped and reversed at frequent intervals.

For such work, whatever type of motor is employed, some form of automatic control is necessary, and it is obviously desirable that such gear should be at least equal in reliability to the motor. Probably one of the most severe tests of reliability of electric motors and control gear is its application to the driving of auxiliary machinery in steel works. The live rolls for rolling mills, for instance, may have to be started, stopped and reversed some hundreds of times per hour, and when it is remembered that a stoppage of the live rolls would throw the whole mill out of action, it will be understood that the design and construction of the control gear for operating them electrically calls for very careful consideration.

The illustrations which are given on the opposite pages show a type of control gear for induction motors of the wound-rotor type that has given complete satisfaction in the particular service above referred to, as well as in other similar applications involving severe working conditions. It is made by Messrs. Electric Control, Limited, Bridgeton, Glasgow, and is known as the "Eddystat" rotor controller, from the fact that the surplus power supplied to the stator while the motor is accelerating is absorbed in eddy-current losses instead of in ohmic heating as is more usual. The controller itself has no moving parts, and unless the motor is to run continuously in one direction, the former is left permanently connected to the rotor windings through the slip rings; if continuous running in one direction is required, a switch is provided to short-circuit the controller when the motor is running at full speed.

The external appearance of one type of the "Eddystat" is illustrated in Fig. 1, while Fig. 2 shows its construction, and Fig. 7 is a diagram of connections in which the controller is indicated by the letter C. It consists of three solid-steel cores on which the windings are fitted in the form of separated coils to provide good ventilation, the three cores being connected at each end by cast-steel yokes formed with fins to assist in the dissipation of the heat generated. When current is first switched on to the motor stator with the rotor at rest, the maximum rotor voltage at the full line frequency will be impressed on the controller, so that the eddy-current losses will be large. As the rotor run up, however, the rotor voltage and frequency both diminish in inverse ratio to the speed until the rotor is running at full speed when the frequency and voltage applied to the controller will be proportional only to the slip. For many purposes, the controller losses would be negligibly small, but, as previously mentioned, they can be entirely eliminated by fitting a short-circuiting switch.

To reverse the direction of rotation of a three-phase induction motor it is only necessary to interchange the connections of two of the leads to the stator windings, and this is effected, in the case of the apparatus we are considering, by means of two pairs of contactor switches operated by a master controller. For reversing, the "Eddystat" controller has the important advantage that it acts as a very powerful electric brake which greatly reduces the time required for reversal and thus increases the output of the plant driven by the motor. The braking effect arises from the fact that if the connections of two of the stator leads are reversed, the direction of rotation of the field produced by the stator windings will be reversed, so that while the rotor is running at full speed in the original direction of rotation, the voltage and frequency of the current applied to the controller windings will both be twice as great as that applied when the rotor is stationary. The high voltage and frequency of the current in the rotor windings produce heavy eddy currents in the solid cores, so that the surplus energy is rapidly absorbed and dissipated in the form of heat. The line current taken when reversing in this way is very little in excess of the normal starting current, so that it is impossible for the operator to damage either the motor or the controller by reversing too rapidly. The motor and gear controlled by an "Eddystat" controller are not subjected to so many shocks as those controlled by an ordinary resistance controller, as the Eddystat accelerates the motor and gearing up quite smoothly, whereas with a resistance starter the motor and gearing are subjected to a shock as each step of resistance is cut out.

With further reference to Fig. 2, it should be mentioned that the windings have been removed from the central limb in order to show the solid-iron core. It will also be noticed that each winding, one of which is connected in each phase, is provided with a number of tappings. To suit various requirements as to starting torque, different tappings can be selected and adjustments can also be made by altering the connections of the windings so as to place different numbers of turns in series-parallel or to connect the phases in either star or delta; a very wide range of adjustment is obtainable by these means. The coils, we may add, are specially designed to withstand very high temperatures.

A photograph of a double-pole reversing stator contactor panel for use with the "Eddystat" rotor controller, and specially designed for steel works' service, is reproduced in Fig. 3, while the construction of the switches and operating magnet can be followed by examining the drawings given in Figs. 4, 5 and 6. The whole of the electrical connections are shown in Fig. 7, in which the master controller is indicated by the letter A, and the contactor switches by the letter B. The operating magnets shown to the left of Figs. 3 and 4, and also in Fig. 5, call for no particular comment. Both the core and armature are, of course, formed of iron laminations. The armature is clamped to a square shaft to which the arms of two contactor switches are also clamped, so that when the magnet is energised and the armature drawn up to the core, the shaft is rotated and the movable contacts on the switch arms are brought into contact with fixed contacts mounted on the panel. The shaft, it should be mentioned, is insulated with moulded mica and served with silk tape to prevent the mica from flaking off.

The construction of the contactor switches is best shown in Figs. 4 and 6, and it will be noticed that each is fitted with a magnetic blow-out, the coil of which is wound with copper strip on edge. The arc shields are of a special arc-resisting material and are arranged so that they can be easily lifted up for the purpose of examining the contacts. These are of hard-drawn thick

THE VAN WEST GEAR TOOTH TESTING APPLIANCE.

Fig. 1.

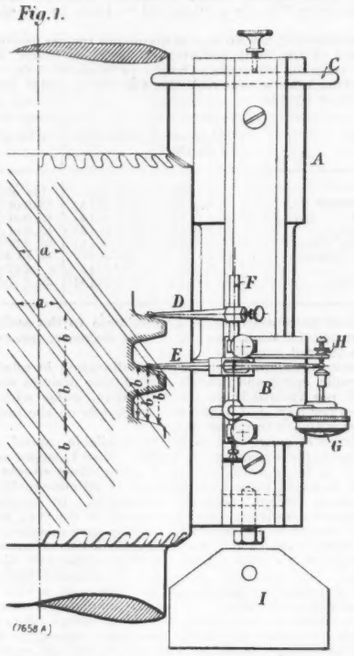


Fig. 2.

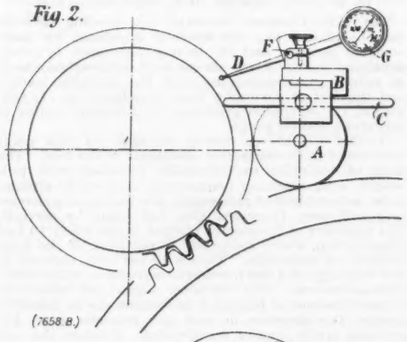


Fig. 3.

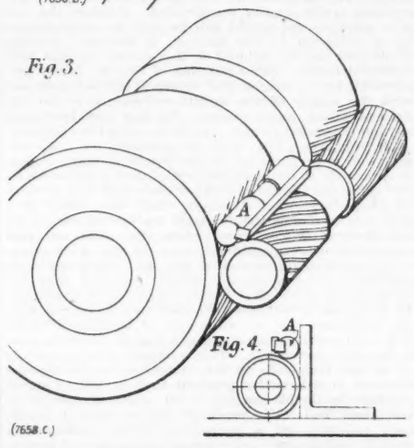


Fig. 4.

AUTOMATIC CONTROLLER FOR INDUCTION MOTORS.

CONSTRUCTED BY MESSRS. ELECTRIC CONTROL LIMITED, ENGINEERS, BRIDGETON, GLASGOW.

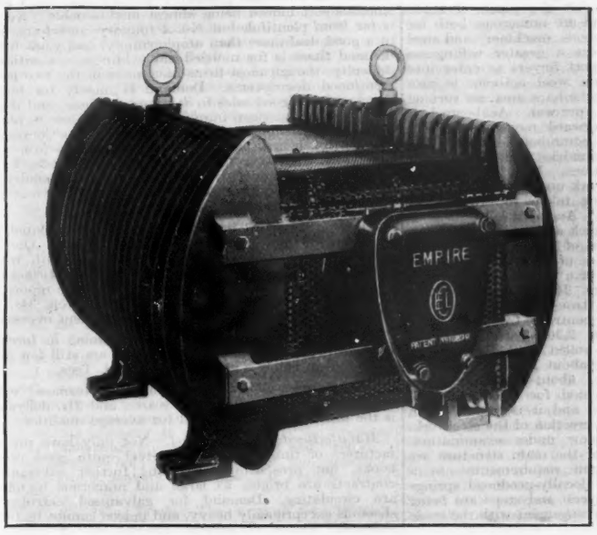


FIG. 1.

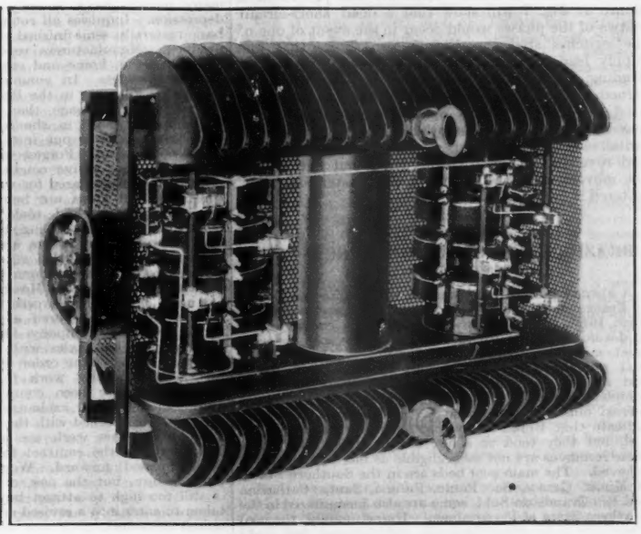


FIG. 2.

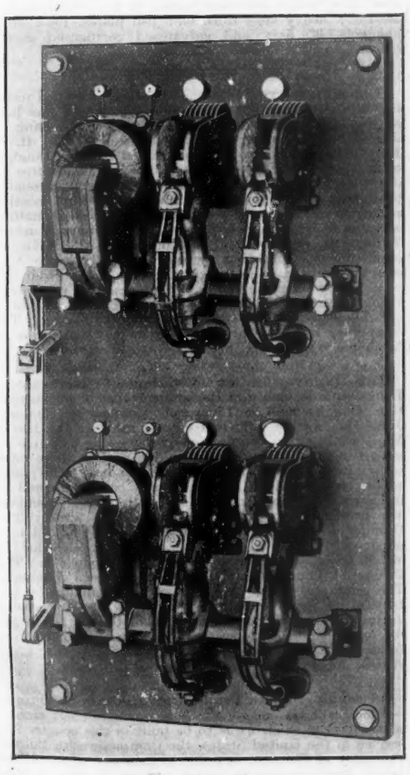


FIG. 3.

FIG. 4.

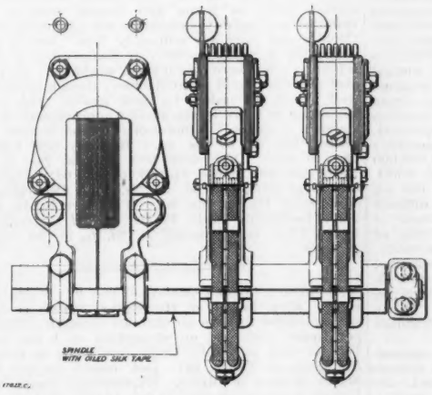


FIG. 5.

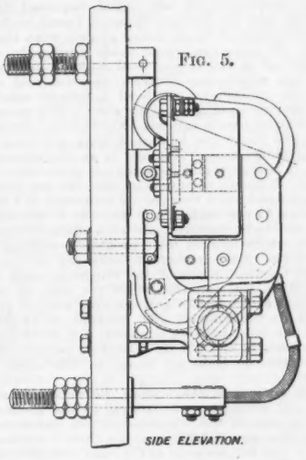


FIG. 6.

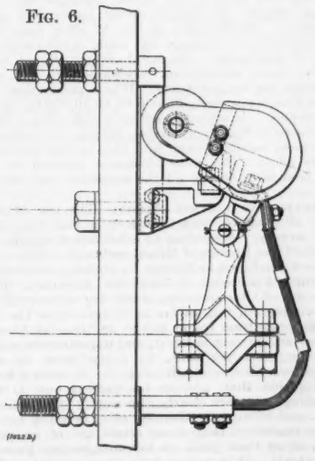
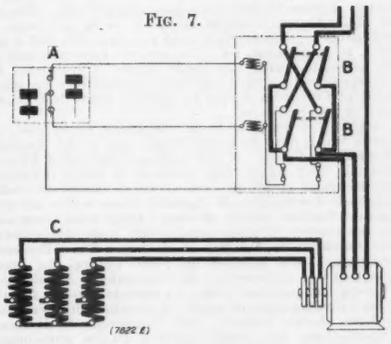


FIG. 7.



copper strip, of the form shown by the dotted lines in Fig. 6, and both fixed and moving contacts are interchangeable to facilitate renewals. The moving contacts are mounted on a contact carrier, pivoted to the main-switch arm, and the design is such that when the switch is closing, the moving contact first touches the fixed contact and then rolls over it as the switch is pressed home, this action breaking any weld that may have formed at the moment of first contact. From the first point of contact to the fully-closed position, the force tending to close the contactor continually increases, owing to the fact that the air gap between the core of the magnet and the armature is decreasing in length, while the opposing resistance of the specially designed spring remains nearly constant. As a result of this arrangement, the contacts are closed rapidly and, at the same time, the tendency to welding is avoided. When the switch is opening, the contacts, of course, roll over each other in the opposite direction. With the rolling action above described, and with sufficient pressure always maintained, the makers claim that a line contact is sufficient for the heaviest currents, the heat being rapidly conducted away from the parts in actual contact by the surrounding copper. The contacts used for currents of above 100 amperes are all 1 in. in width, the larger sizes having two or more contacts in parallel, which greatly simplifies the question of spares. Few of the latter are necessary, however, since the contacts are extremely durable; tests carried out by the firm indicate that even after 2,000,000 operations the contacts remain quite serviceable.

Current is conveyed to the movable contacts by a

pair of braided flexibles of circular section, which, as shown in Fig. 6, are placed quite clear of the switch arm so that heat is rapidly dissipated. The mechanical interlocking gear, shown in the left of Fig. 3, is provided to prevent one pair of switches from being closed until the other is open, Without this provision, a glance at Fig. 7 will show that a dead short-circuit on two of the phases would occur in the event of one of the switches sticking. Fig. 7 also shows that one supply lead is permanently connected to the stator winding, as far as the reversing contactors are concerned, but a three-pole main switch is generally used to disconnect the machine completely when necessary. In ordinary working, however, the main switch is closed, and the operations of starting, stopping and reversing the motor are carried out entirely by the movement of the handle of the master controller, lettered A, in Fig. 7.

BRAZILIAN MINERAL RESOURCES AND METALLURGY.

A RECENT publication issued by the Comité des Forges de France states that during recent years, and especially since 1918, the Brazilian Government is endeavouring to develop and to turn to account on the spot the very great mineral resources of the country. In regard to coal reserves, owing to the very large area of Brazil and the lack of means of communication, any very complete study of the substrata has not as yet been carried out. Researches so far made would appear to indicate that Brazil is not particularly rich in mineral fuel, but they tend to show, on the other hand, that these resources are not so negligible as has been hitherto believed. The main coal beds are in the Southern States of Minas Geraes, Sao Paulo, Parana, Santa Catharina and Rio Grande do Sul; some are also encountered in the Northern State of Pernambuco. Unfortunately, the coal seams are of no great thickness and the coal they yield is of indifferent quality only, and contains in some instances a high percentage of sulphur and generally a large proportion of ash. Coal imported from Great Britain and the United States is found to be cheaper, besides being of much better quality than the Brazilian fuel. Recent experiments made during the war, owing to the fall in the foreign coal imports, have shown that the less sulphurous Brazilian class of coal could very well be utilised in the local industrial establishments and also be used for making coke. The present annual coal output hardly exceeds 400,000 tons. It is reckoned that new plant now being put down will raise this figure to 1,000,000 tons. Charcoal is an important Brazilian fuel, it is cheap, and its supply is practically unlimited.

The Brazilian resources in iron ore are considerable; the present known reserves are estimated at 8,000,000,000 tons, or 23 per cent. of the reserves of the whole world. The ore beds, however, are at a distance from the sea coast, which renders their profitable working a difficult one. The most important beds are in the State of Minas Geraes. Some of the ironstone, such as that of Pico d'Itabira, contains 98·90 per cent. of iron oxide. 0·37 per cent. of silica and 0·02 per cent. of phosphorus, Generally the analysis is 50 per cent. to 72 per cent. Fe 0·09 per cent. to 0·44 per cent. Mn, 0·01 per cent. to 2 per cent. P, and 0·1 per cent. to 2 per cent. Si. Other important ore beds are found in the other Brazilian States.

The country is also one of the richest in manganese ore, and since the war, owing to the Russian output having ceased, the Brazilian output has increased. In 1913, this was 122,300 tons, in 1915 it reached 288,671 tons; 532,855 tons in 1917; and was 393,584 tons in 1918. Numerous beds have been mapped out. The ore of Matto-Grosso contains as much as 85 per cent. of manganese. The average is 45 per cent. Mn and 8 per cent. to 10 per cent. Fe. The reserves have not been so far estimated with any great degree of certainty, for numerous regions have still to be prospected; the single mine of Corrumba is said to contain about 100,000,000 tons of manganese ore.

Pig-iron is being made at the Usina Esperança, the Usina Wigg, both in Minas Geraes, and at the Spanema Works, San Paulo. A new company formed of French, Belgian, and Luxemburg interests is being developed in the State of Minas Geraes, whilst others are being established with British capital. These works are also laid out for the making of steel. Apart from these, and in the matter of steel manufacture more particularly, the Fundiçao de Aço Sao Paulo has a 2-ton Bessemer converter; the Estrada de Ferro Central do Brazil has a 1-ton converter; the Companhia Metallurgica Mineira has just put down an electric furnace for the direct manufacture of steel; a Swedish firm operates a 1-ton electric furnace; the Companhia Mechanica e Importadora, Sao Paulo, owns a 20-ton open-hearth furnace and a bar mill; Messrs. Hime and Co. have a rolling-mill near Rio de Janeiro; and the Campanhia Paulista de Estradas de Ferro contemplates putting down a steel works.

UNIVERSITY OF LONDON, KING'S COLLEGE.—The college has issued a list of public lectures to be held in the Lent term, 1923. It includes a course of public lectures on "Some Aspects of Natural Philosophy"; also advanced lectures in the Department of Engineering. Admission to these lectures (except to students of the college) is only permissible on payment of a fee for the course, particulars of which, together with a copy of the list, can be obtained from the Secretary's Office, Strand, W.C. 2.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The signs of improvement noted towards the end of last year are becoming more pronounced, and are extending to departments which for many months have severely felt the pinch of trade depression. Inquiries all round are numerous, both for basic materials, semi-finished goods, machinery and steel products. Manufacturers report a greater willingness on the part of home and export buyers to enter into forward business. In common steel activity is pronounced. Furnaces in the Rotherham area are turning out a bigger tonnage than pre-war. Acid steel is beginning to share in the forward movement. More furnaces have been put into commission to meet the increased demand. Forges, foundries and rolling mills all report more active conditions. Most of the plans have now been prepared for work under the new cruiser contracts, and steps are being taken to provide the requisite material and tools. An active business is being done in railway rolling stock and materials. Some of the most recent orders are of rather a substantial character. The unsettled state of affairs in Germany has resulted in the diversion of a considerable amount of work to this area. Messrs. John Baker and Co., Limited, of the Brinsworth Iron and Steel Works, Rotherham, have secured a contract from the East Indian Railway Company for 2,300 pairs of broad-gauge wheels and axles with rolled steel disc centres. The total value of the order is about 100,000*l.*, and will furnish six months' work for about 800 men. The foundations have been completed for Sheffield's new automatic telephone exchange, and it is hoped at an early date to proceed with the erection of the steelwork. Tenders for this work are now under examination. The details of the contract for the main structure are being pressed forward. Wagon requirements are a busy feature, but the cost of locally-produced springs is still too high to attract buyers, and steps are being taken to enter into a revised arrangement with the trade unions concerned.

South Yorkshire Coal Trade.—The colliery position strengthens almost weekly. The majority of buyers on industrial account have given up hope of easier rates and are entering into contracts for deliveries over the next three to six months. Best steam hards are a good market both on home and export account. Blast furnaces and railway companies are prominent buyers. Cobbles and nuts are uniformly firm. Better quality slacks are in ready demand at rising rates, though in inferior grades there is still some weakness. The house-coal position is still unsatisfactory, though collieries are well placed for orders for best grades. Gas coke is beginning to share in the steady improvement in blast-furnace qualities. Quotations:—Best branch hand-picked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 9*s.* to 11*s.*; nutty slacks, 7*s.* 9*d.* to 9*s.* 9*d.*; smalls, 3*s.* to 5*s.*

ALUMINIUM-COPPER ALLOYS.—The 92 : 8 aluminium-copper alloy, known in the United States as No. 12, can be trusted to have an ultimate strength of 18,000 lb. per square inch and an elongation of 1 per cent. to 1·5 per cent. in a 2-in. length, according to Robert J. Anderson, in Paper 287, just issued by the United States Bureau of Mines. Experiments made by the Bureau in the preparation of No. 12 alloy do not indicate that one rich alloy is any better than another for introducing copper, as regards dross losses and gas consumption. Small heats of No. 12 alloy may be made conveniently and cheaply by using light-gauge copper sheet or punchings; the solid copper should be added to the liquid aluminium, whereupon it will alloy at relatively low temperatures. Where production is large, as in a foundry pouring 25,000 lb. to 50,000 lb. of castings in 10 hours, it is safer to employ a rich alloy. The most convenient rich alloy available, taking into consideration brittleness, melting-point, and ease of calculation, is the 50 : 50 alloy. The most desirable method of making up a heat is to charge all the materials together.

TITANIUM AS A STEEL ALLOY.—The use of titanium as an alloying element for steel is still the subject of much secrecy. According to information supplied to the United States Bureau of Mines, carbon-free ferro-titanium has been employed in Europe for making an electric steel containing 5 per cent. to 7 per cent. titanium. Rumours of the use of titanium-alloy steels for armour-plate have been circulated, but so far as is known to the Bureau, no merit has been found in the addition of titanium to steel as an alloying element, and experiments with steels containing 0·1 per cent. to 1 per cent. of titanium have shown no special advantages. A more interpretive investigation than any so far carried out, is required to distinguish more clearly the merits of titanium-alloy steels, and it must be assumed now, pending exact proof to the contrary, that these steels are of no particular value, or at least yield no advantages not provided by other steels. It is rather difficult to get the carbon-free ferro-titanium to alloy with steel without much loss of titanium, and this fact, coupled with the high price of the carbon-free alloy, has tended to discourage experimentation by steel makers in this direction. It is possible, however, that if the cost were less, some combination of titanium, either alone or with other metals, might produce valuable steels for some purposes, and experiments need to be carried out.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Scarcity of the better qualities of Cleveland pig-iron is pronounced, No. 1 and siliceous sort indeed being almost unobtainable. No. 3 is far from plentiful, but No. 4 foundry and forge are in a good deal more than ample supply, and what little demand there is for mottled and white is met without difficulty, though most firms have none of the two last-mentioned descriptions. Demand is mostly for home use, but fairly good sales to Scotland continue, and there is still some American inquiry for qualities low in phosphorus and in sulphur. At the moment sales to Continent are hardly heard of. No. 1 and siliceous iron are nominally 97*s.* 6*d.*; No. 3 g.m.b. is now 93*s.* f.o.t. makers' works, and 94*s.* f.o.b. Tees; No. 4 foundry is round about 88*s.* 6*d.*; No. 4 forge 85*s.*; and mottled and white are put at 80*s.*

Hematite.—In this branch supply is hardly equal to requirements and prices are moving upward. Quotations, however, are still low as compared with rates ruling for other irons. In addition to the satisfactory home business passing a few sales to Italy are reported. Nos. 1, 2 and 3 East Coast brands range from 94*s.* to 95*s.*, both for home purposes and for shipment overseas.

Foreign Ore.—There is rather more doing in foreign ore and prices are stiffening, but sales are still few and small. Best rubio is about 23*s.* 6*d.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke keeps very strong. Supply is scarce, and 31*s.* delivered is the minimum figure named for average qualities.

Manufactured Iron and Steel.—Not only have manufacturers of finished iron and steel quite good order books, but prospects of securing further substantial contracts are bright, as large and numerous inquiries are circulating. Demand for galvanised corrugated sheets is exceptionally heavy, and indeed cannot be fully satisfied. Prices of several descriptions of material have been advanced. Among the principal market quotations are:—Common iron bars, 11*l.*; steel billets, 8*l.* to 9*l.*, according to quality; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 5*s.*; steel angles, 8*l.* 15*s.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; steel channels, 9*l.* 5*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 18*l.* 10*s.*

THE WHITWORTH SOCIETY.—A largely-attended meeting of Whitworth scholars and exhibitioners was held at the Institution of Mechanical Engineers building on the 12th inst., under the chairmanship of Dr. H. S. Hele-Shaw. The meeting determined on the founding of a Whitworth Society and elected a committee to draw up a constitution and rules. It is not intended that the society should compete with any existing society in any way. It will mainly be of a social nature, and one of its chief activities will be a dinner at which Whitworth scholars and exhibitioners will have an opportunity of meeting together annually. The hon. secretary of the society is Mr. E. R. Dolby, who will be glad to receive the names and addresses of Whitworth scholars and exhibitioners who so far have not been communicated with in connection with the matter The temporary office of the society is at the Institution of Mechanical Engineers, Storey's Gate, Westminster.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—It has been decided that the summer visit of the Institution shall be held in Liverpool, commencing Monday, June 18. As the T.T. motor-cycle races in the Isle of Man terminate on the previous Friday this will give an opportunity to those who are taking part in those races to join in the visit on the following Monday. The places to be visited will be almost entirely works devoted to industries differing from those with which members are brought into contact in their daily work. The Daimler premium of 25*l.*, annually awarded for the best paper written by a graduate, has been awarded to Mr. M. Platt, of the London Centre, for his paper on "The Design of Connecting Rods for High-Speed Engines." The graduates' prize of 5*l.* 5*s.* offered annually by the Institution for the best paper read before any centre during the session has been awarded to Mr. H. Briggs for his paper on "Repetition Work in the Engineering Industry," the second prize of 2*l.* 2*s.* going to Mr. L. F. Watson for his paper on "Mechanical Efficiency."

40,000-KW. BRITISH TURBO-ALTERNATOR FOR CHICAGO.—What will be one of the largest single shaft turbo-alternators in existence is to be built in this country for service in the United States, the Commonwealth Edison Company of Chicago, in order to gain experience of the latest developments in steam turbine practice in this country, having placed an order with Messrs. C. A. Parsons and Co., of Newcastle-on-Tyne, for a 40,000-kw. turbo-alternator. The 25,000-kw. turbo-alternator which the Commonwealth Edison Company ordered from Messrs. C. A. Parsons in 1912, for their Fisk-street Station, continues to run satisfactorily. The set which has just been ordered is to be installed in the new Crawford-avenue Power Station, Chicago, of which the designed capacity will be about 500,000 kw., the rest of the plant being probably mainly of American manufacture. We understand that the new set, which has a continuous rating of 40,000 kw., is a 60-cycle machine, will be supplied with steam at 550 lb. per square inch, and will run at 1,800 r.p.m. The consulting engineers advising in connection with the matter are Messrs. Sargent and Lundy, of Chicago, and Messrs. Merz and McLellan, of London.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Although work has now been restarted generally in the Scottish steel trade it cannot be said that things are altogether in a very flourishing state yet. A certain amount of work on hand at the end of the year gave something to start on, but since business was resumed bookings have not been over plentiful. In one or two cases, however, there are quite a number of orders on the books and a steady run is assured for the next month or two. Inquiries are again very fair and some of the specifications now in the market amount to a goodly tonnage. All round there is a very hopeful feeling and a gradual but steady improvement is looked for. Plate mills will get better as shipbuilders get on with their orders for new vessels, and it is interesting to note that scarcely a week now passes without intimation being made of at least another fresh shipbuilding order. Makers of structural sections are a bit better off for work and the prospects are rather encouraging. In the black steel sheet trade the demand has improved both on home and export account. The general export trade, while better than it has been for some time past, is somewhat slow, but a steady expansion is highly probable as the weeks go on. Prices are firmly maintained and are as follow:—Boiler plates, 12*l.* per ton; ship plates, $\frac{3}{8}$ in. and up, 8*l.* 15*s.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; and sheets, $\frac{1}{4}$ in. to $\frac{1}{2}$ in., 10*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—Conditions in the West of Scotland malleable iron trade show little change over the week, but are, if anything, the turn better. The home demand shows a slight improvement and inquiries are more numerous than they have been of late. One feature of the industry at the moment is the firmness with which sellers are quoting their prices, and "crown" bars are strongly held for 10*l.* 10*s.* per ton, delivered Glasgow stations, makers being unwilling even to shade that figure.

Scottish Pig-Iron Trade.—The market for Scottish pig-iron has been rather more active during the past week, mainly on home account, as the export demand has fallen off very considerably. There is a fair amount of business passing for foundry grades, and an increasing number of orders have been booked for hematite for the steel works. Inquiries are also very satisfactory and signs are not wanting that consumers are beginning to look a little ahead in anticipation of quotations advancing slightly in the near future. To-day prices are named as follow:—Hematite, delivered at the steel works, 5*l.* 7*s.* 6*d.* per ton; foundry iron, No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, on trucks at makers' works.

Scottish Pig-Iron Shipments.—The total amount of Scottish pig-iron shipped at Glasgow harbour during the week ending Saturday, January 13, was 3,033 tons, all of which, except 87 tons, went foreign, the latter tonnage going coastwise. For the same week last year there was nothing shipped abroad and only 10 tons went coastwise.

Scottish Shipbuilding.—An order for a cargo steamer of 8,000 tons deadweight has been placed by Messrs. R. S. Dalgliesh, Limited, shipowners, Newcastle-on-Tyne, with the Blythswood Shipbuilding Company, Limited, Scotstoun. This vessel is to be propelled by triple-expansion reciprocating steam engines. Orders have been secured by the Ailsa Shipbuilding Company, Limited, Troon, to build two steamers, each of 1,130 tons gross, for Messrs. William Sloan and Co., shipowners, Glasgow. These two vessels will be similar in most respects to the Findhorn, built in 1903, and the Annan, built in 1907, for the same owners.

Clyde Shipyard Changes Hands.—The Whiteinch shipyard known as the River Clyde Shipbuilding Works, and operated for some time by the Lloyd Royal Belge Company, of Antwerp, under the title of the Lloyd Royal Belge (Great Britain), Limited, has changed hands. The new owners are the Australasian United Steam Navigation Company, Limited, the chairman and managing director of which is Lord Inchcape. It is understood that the yard will be reopened in the near future under the management of one of the shipbuilding firms in the upper reaches of the Clyde, it having been closed for exactly two years. The reason for suspending operations in January, 1921, was the high cost of construction, and at that time there were four vessels at different stages of construction. It is probable that the new owners will complete these vessels when work is restarted. The above shipyard was formerly owned by Messrs. John Reid and Co.

Proposed Dry Dock for Burntisland.—A proposal was recently made for the construction of a dry dock at Burntisland, but it has now been ascertained that the railway company will not sell the necessary ground outright, although willing to consider an offer for a lease. This latter has now been submitted and if terms can be agreed upon the scheme is likely to be undertaken very soon. It may be noted here that the local shipbuilding company recently booked other two orders, making a total of seven vessels booked during the past two months.

THE WALNEY ISLAND AIRSHIP SHED.—We understand that the airship shed built by Messrs. Vickers, Limited, on Walney Island, near Barrow-in-Furness, in 1913, being no longer required for airship construction, is now available for use in connection with cinematograph film production work. The dimensions of the main building, which we illustrated on page 758 of our 107th volume, render it particularly suitable for this class of work, for which a large amount of covered space, with ample head room, is required. The numerous auxiliary buildings on the site should also prove capable of use in connection with this particular application.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—In December, 2,261,886 tons of coal were shipped from South Wales to foreign ports, of an f.o.b. value of 2,636,359*l.* This was 110,502 tons less than in November and the revenue was 211,992*l.* less. It must, however, be remembered that there were two less working days in December on account of the intervention of the Christmas holidays, and this two days' suspension of work was entirely responsible for the decline in the aggregate volume of trade. In fact, the average daily shipment of coal in December was greater than in November, and almost up to the record level reached in September. Shipments from Cardiff totalled 1,397,690 tons, or about 20,000 tons less than in November; from Newport 455,980 tons, an increase of 1,000 tons; from Port Talbot 199,748 tons, a reduction of 37,000 tons; and from Swansea 208,468 tons, a decrease of 54,000 tons. The quantity exported in December was 5 per cent. less than in November, but the value of the shipments showed a decline of just over 7 per cent. The total shipments of large steam coal in December amounted to 1,394,320 tons of an average f.o.b. value of 26*s.* per ton, or 2*d.* more than in November, but steam smalls aggregated 677,552 tons, valued at 16*s.* 4*d.* per ton, a decrease of 2*d.* Large exported from Cardiff averaged 26*s.* 4*d.*, against 26*s.*, from Newport 25*s.* 1*d.*, or the same as in November, from Swansea 26*s.* 10*d.* against 26*s.*, and from Port Talbot 26*s.* 4*d.* against 26*s.* 6*d.* Steam smalls shipped from Cardiff averaged 16*s.* 2*d.* as in November, from Newport 18*s.* against 18*s.* 4*d.*, from Port Talbot 14*s.* 3*d.* against 14*s.* 8*d.*, and from Swansea 16*s.* against 17*s.* 6*d.* Large anthracite exported from Swansea showed a further heavy fall both in respect of quantity and value. In December 49,104 tons were shipped compared with 87,207 tons, and the value fell from 47*s.* 11*d.* per ton to 41*s.* 3*d.* There was also a slump in anthracite small, the quantity exported in December at 58,814 tons, comparing with 72,513 tons in November, and the value at 19*s.* 1*d.* with 26*s.* 3*d.* At present the inquiry for Welsh coal is very active and forward prices are firm. In fact, many colliery salesmen refuse to take on further business for shipment ahead. The United States are in the market for single cargoes and also for quantities varying from 75,000 tons to 100,000 tons with prompt shipment, and tonnage is also wanted to lift 40,000 tons of coal for Canada, commencing in March. The Egyptian State Railways want offers for 35,000 tons, the Mauritius Government for 30,000 tons, the Norte Railways of Spain 20,000 tons, and the Dutch State Railways 10,000 tons, while there is also a French inquiry for 50,000 tons. The Germans, too, are reported to be negotiating the financing of heavy supplies. The Paris, Lyons and Mediterranean have booked up orders for about 120,000 tons of large and small coal, mainly smalls, for delivery over the next six months. Colliery companies are hampered in reaping the full advantage of the business offering by reason of the inadequacy of loading facilities. To-day there were nearly 300 vessels in the Cardiff, Penarth, Barry and Newport docks, of which 86 were under the tips, but there were still 34 vessels waiting for berths. Most collieries have full order books, yet have been compelled to effect temporary stoppages because of the lack of loading accommodation. Best steam large coals are firm at 28*s.* 6*d.* and smalls at 18*s.* 6*d.* to 19*s.* Dry large is weak at 27*s.* for best and 26*s.* for ordinaries, but smalls are firm at 14*s.* to 15*s.* 6*d.*, according to quality.

AEROPLANE DESIGN.—The paper on "Aeroplane Design," read by Mr. H. P. Folland, M.B.E., F.R.Ae.S., before the Institution of Aeronautical Engineers, on March 31 last, has been reprinted, together with the discussion, in the form of a booklet, and is obtainable from the offices of the Institution at 60, Chancery-lane, W.C. 2, price 2*s.* 6*d.* n t. In this paper, which appeals mainly to engineers and draughtsmen, the author goes over the preliminary design of an aeroplane, giving the necessary approximations, and also draws attention to matters of detail design. A large number of lantern slides were used to illustrate the original paper, and these are all reproduced at the end of the reprint.

THE INTERNATIONAL AIR CONGRESS.—The principal object of the Congress which is to be held in London from Monday, June 25, to Saturday, June 30 next, is to give an opportunity for international discussion of various problems in connection with aircraft design, construction and operation. The papers will be divided into four groups which will be dealt with in sessions held simultaneously, the groups being devoted to (*a*) aerodynamics, aeroplane construction, research methods, &c.; (*b*) power plants, fuels, lubrication, airscrews, &c.; (*c*) air transport and navigation; (*d*) *personnel*, air tactics and strategy (as affecting commercial design), airship design and construction, &c. Members will also have an opportunity of visiting various British aircraft establishments and factories, and the Air Ministry have arranged to hold the Royal Air Force Pageant on June 30—the last day of the Congress. Membership is open to nationals of all countries which are represented on the Fédération Aeronautique Internationale, or which are signatories of the International Air Convention. The subscription for membership will be 1*l.*, and members of the same family as a member may join as associate members for a subscription of 10*s.* each. The official languages of the Congress will be French and English. Lieutenant-Colonel W. Lockwood Marsh, 7, Albemarle-street, W. 1, has been appointed general secretary, and further particulars may be obtained from him.

NOTICES OF MEETINGS.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Friday, January 19, at 7.30 p.m., at the Philosophical Hall, Leeds. Paper, "The Legal Aspect of Underground Water," by Mr. H. F. Bidder, D.S.O., M.A., Barrister-at-Law.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 19, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "Laminated Springs," by Mr. T. H. Sanders. Friday, January 26, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "K.V.A. and Its Measurement" (Demonstrations), by Mr. G. F. Shotter.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 19, at 6 p.m., at Storey's Gate, St. James' Park, S.W.1. A symposium of papers on "Indicators." Four papers are to be read, as follows: "The Problem of the Engine Indicator," by Mr. L. Pendred; "A New Form of Optical Indicator," by Professor Burstall; "A Micro-Indicator for High-Speed Engines," by Mr. W. G. Collins; and "R.A.F. Electrical Indicator for High-Speed Internal-Combustion Engines and Gauge for Maximum Pressures," by Mr. H. Wood, R.A.F.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Saturday, January 20: Visit to Messrs. Doxford's, Pallion Engine and Shipbuilding Works, Sunderland. Tuesday, January 23, at 7.15 p.m., at Armstrong College, Newcastle-upon-Tyne. "The Desert Campaign and Advance on Jerusalem," by Professor Morrison, M.A., D.Litt., F.R.S.C.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS: SCOTTISH CENTRE.—Monday, January 22, at 7.30 p.m., at the Royal Technical College, George-street, Glasgow. Address by Professor Dalby, M.Inst.C.E., M.I.Mech.E., F.R.S., on "Mechanical Transport and Some of its Problems."

THE BRADFORD ENGINEERING SOCIETY.—Monday, January 22, at 7.30 p.m., at the Bradford Technical College. "The Manufacture and Uses of Acetylene Gas," by Messrs. Allen Liversidge, Limited, of Hull. With exhibition of cinematograph film.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Tuesday, January 23, at 3 p.m. Afternoon Lectures: "Semi-Permeable Membranes and Colloid Chemistry: (2) Relation to Problems of Colloid Chemistry and Biology," by Professor F. G. Donnan, D.Sc., F.R.S., M.R.I. Thursday, January 25, at 3 p.m.: "The Campaigns of the British Army, 1815–1838," by the Hon. J. W. Fortescue, C.V.O., LL.D. Saturday, January 27: Sir Walford Davies, Mus.Doc., LL.D., on "Speech Rhythm in Vocal Music" (Lecture II). (Illustrations by members of the Temple Choir.) Friday, January 26, at 9 p.m.: Evening Discourse will be delivered by Sir Almroth Wright, K.B.E., C.B., M.D., "The Machinery of Anti-Bacterial Defence."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 23, at 6 p.m., at Great George-street, S.W. 1. Ordinary Meeting. Papers to be submitted for discussion: "Railway Economics for Extra-European Railways," and "Reinforced Concrete on the Chinese Railways," by Mr. Harold Stringer, B.A., Assoc.-M.Inst.C.E. Wednesday, January 24, at 7 p.m.: Informal Meeting. Subject for discussion: "New Factors in the Reconditioning of Trunk Highways and their Bridges," to be introduced by Mr. R. G. H. Clements, Assoc.M.Inst.C.E.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: SOUTH EASTERN DISTRICT.—Wednesday, January 24, at 4.30 p.m., at 92, Victoria-street, S.W.1. To discuss the question of the present method of election of members to the Council of the Institution referred from the Tonbridge meeting, and other business.

THE WOMEN'S ENGINEERING SOCIETY.—Wednesday, January 24, at 6.15 p.m., at 26, George-street, Hanover-square, W.1. Lecture, "Mechanical Injection of Fuel as Applied to Diesel Engines," by Miss V. Holmes, B.Sc.

THE ROYAL SOCIETY OF ARTS.—Wednesday, January 24, at 8 p.m. "Trueman Wood" Lecture, "New Methods of Crystal Analysis, and their Bearing on Pure and Applied Science," by Sir William Henry Bragg, K.B.E., M.A., D.Sc., F.R.S., Quain Professor of Physics, University of London. Mr. Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, will preside.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, January 25, at 7 p.m., at the Engineers' Club, Coventry-street, W.1. Fifth Annual General Meeting. "The Internal-Combustion Locomotive for Railway Work," by Mr. J. S. Tritton.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, January 25, at 7.30 p.m., at Denison House, 296, Vauxhall Bridge-road, S.W.1. "The Relations between the Architect and the Engineer," by Mr. W. J. H. Leverton, F.S.Arc.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 26, at 7.30 p.m., in the Lecture Theatre, Literary and Philosophical Society, Newcastle-upon-Tyne. Discussion on "Review of Different Types of Marine Internal-Combustion Engines."

THE NEWCOMEN SOCIETY.—Friday, January 26, at 6 p.m., at Queen's College, Paradise-street, Birmingham. Paper on "Some Notes on Windmills to the Commencement of the Nineteenth Century," by Mr. Arthur Titley, M.I.Mech.E.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, January 26, at 7.30 p.m., in the Mappin Hall of the University, St. George's-square. A paper on "Electric Furnaces," by Mr. A. G. Lobley, M.Sc., will be read and discussed.

15-FT. SYKES DOUBLE HELICAL GEAR GENERATOR.

CONSTRUCTED BY THE POWER PLANT COMPANY, LIMITED, ENGINEERS, WEST DRAYTON, MIDDLESEX.

(*For Description, see Page* 69.)

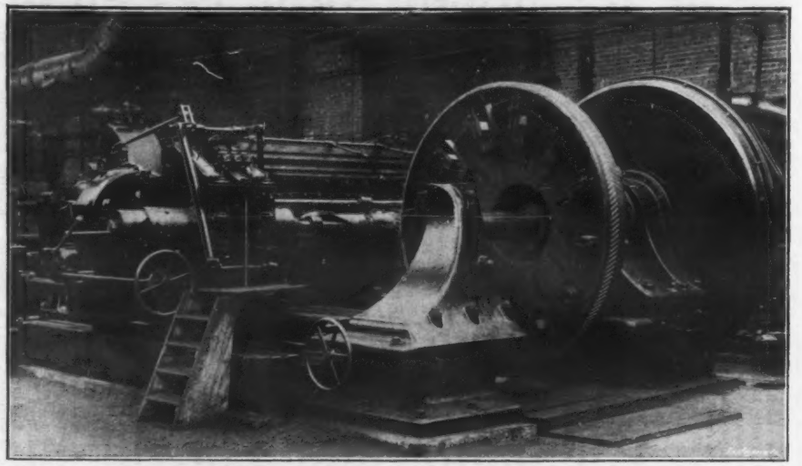


FIG. 8. 9-FT. GEAR RING BEING CUT.

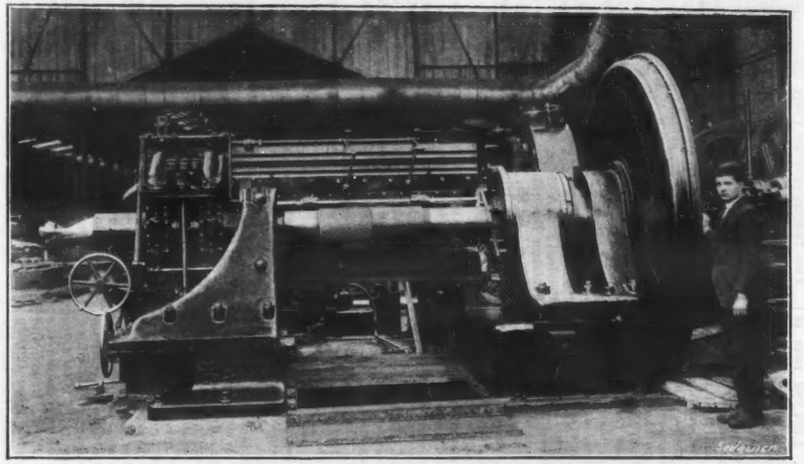


FIG. 9. THE MACHINE CUTTING PINIONS.

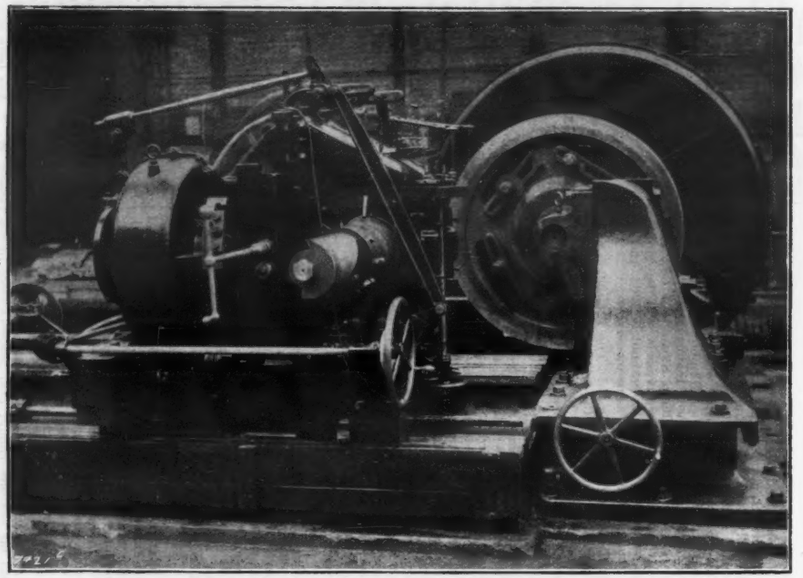


FIG. 10. CONTROL END OF THE MACHINE.

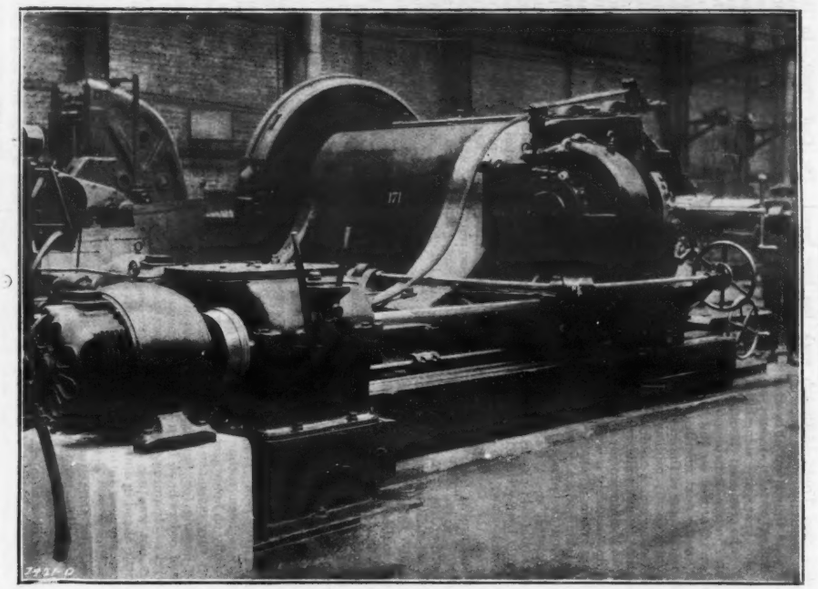


FIG. 11. THE MAIN DRIVING MOTOR AND GEAR-BOX.

Fig. 10. Control End of the Machine.

Fig. 11. The Main Driving Motor and Gear-Box.

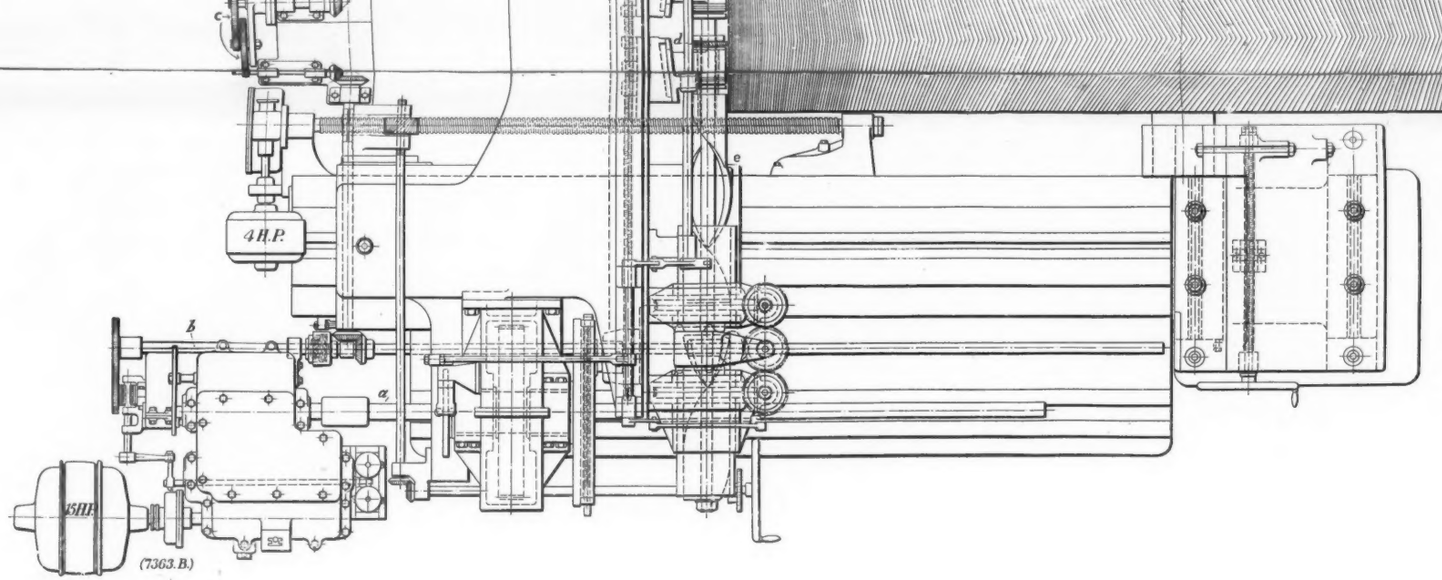
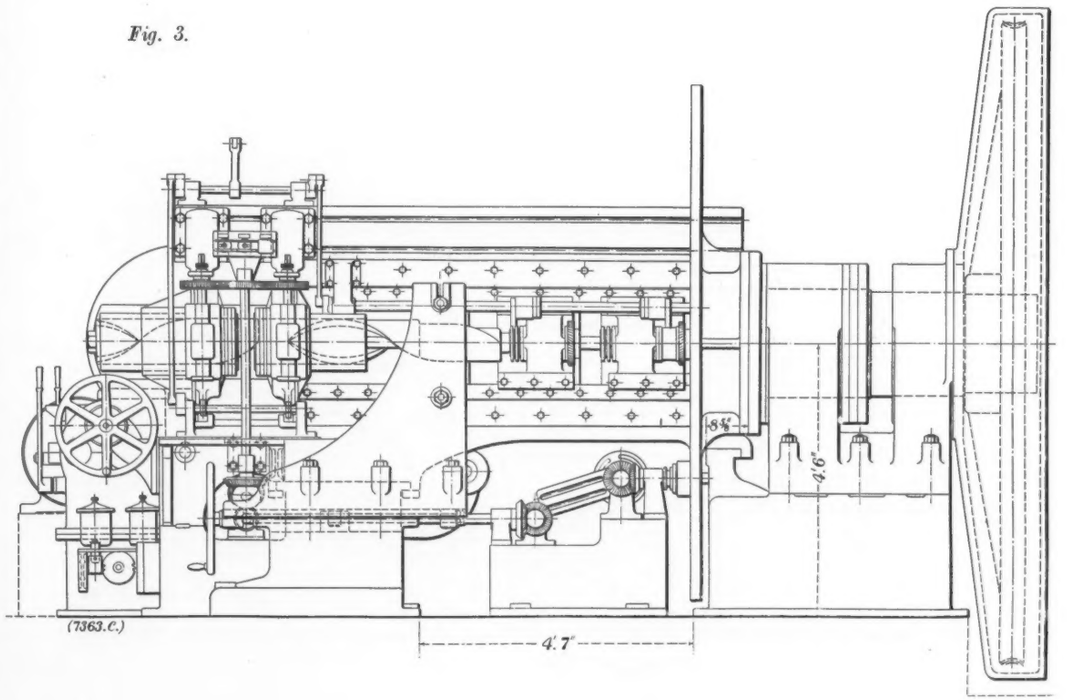


Fig. 3.



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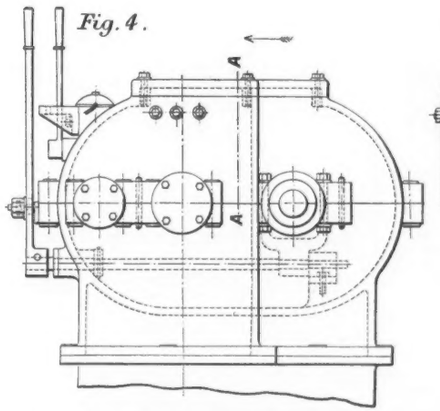

Fig. 5 SECTION A.A. OF TOP HALF SHOWING CHANGE GEAR DETAILS.

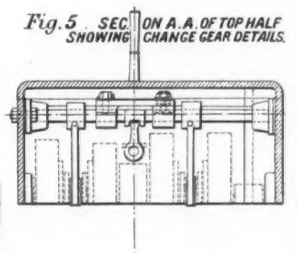

Fig. 6. PLAN WITH TOP HALF REMOVED.

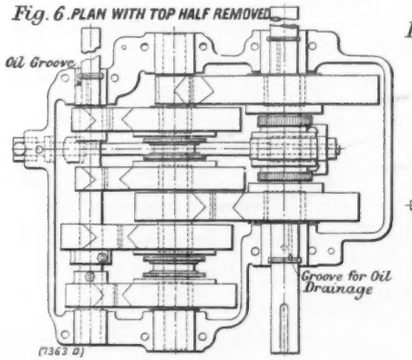

Fig. 7. COVER REMOVED.

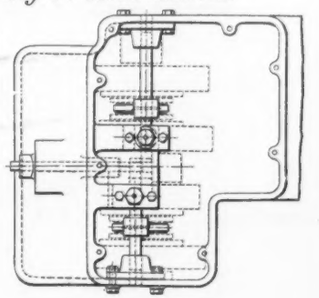

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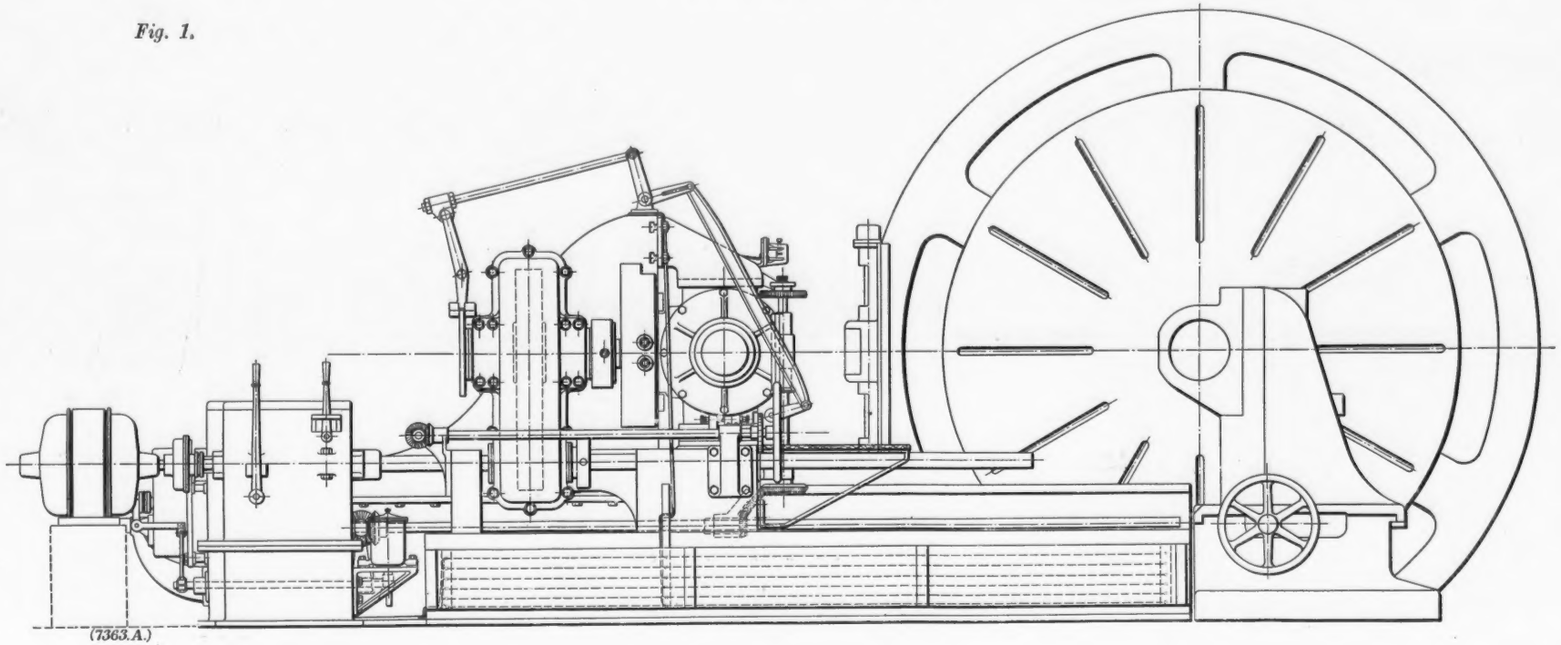
Fig. 1.



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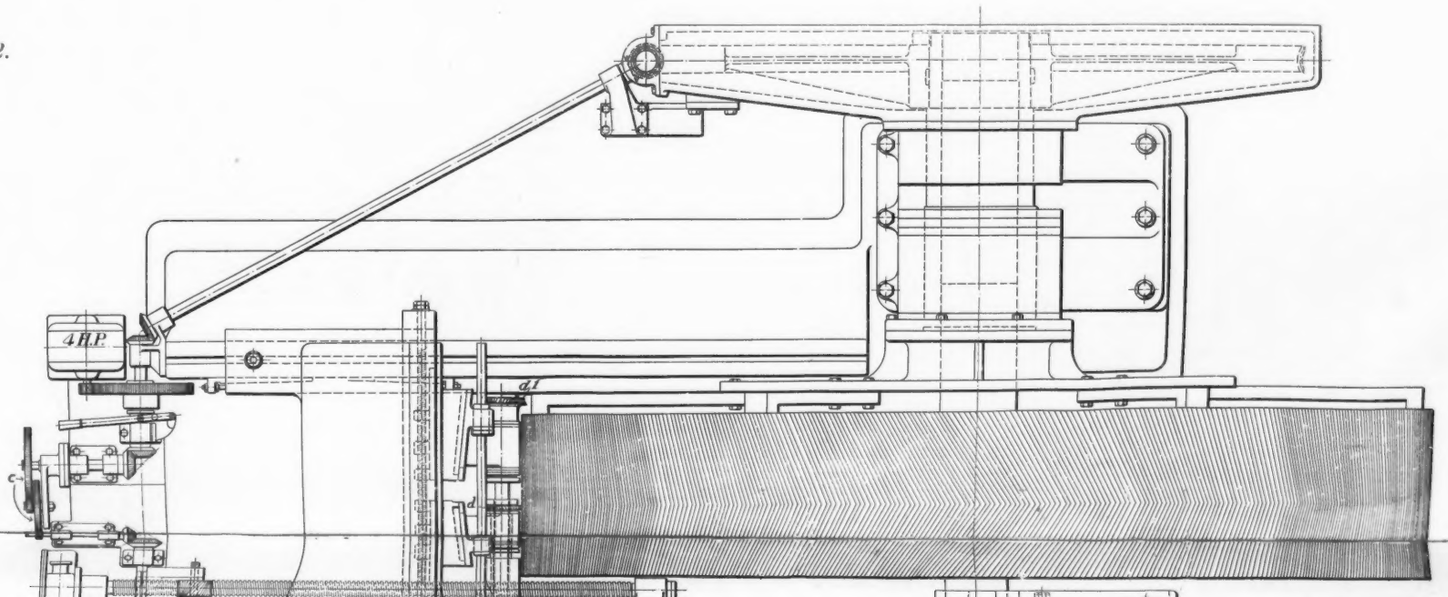

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ENGINEERING.

FRIDAY, JANUARY 19, 1923.

MATERIALISM AND IDEALISM.

As employed to-day in the popular press, the term idealist generally implies a man who has lacked either the energy or, more commonly, the ability to think out to a just conclusion such specious propositions as may present themselves to him. This so-called idealist delights in contemplating and exulting over the consequences that will ensue if his theories are valid, but refrains from any exhaustive inquiry into the soundness of the premises on which they are founded. We meet, of course, with the same type of individual in the engineering field but here he is quickly sized up as a "perpetual motion crank," or the like, and soon ceases to be taken seriously. In other departments of human activity, however, these plausible and self-deceived impostors often attain to positions of considerable influence, owing to a volubility which is characteristic of the type, and it is almost a habit with them to enlarge upon the materialistic character of our modern civilisation. Since all comparisons are necessarily relative, it is to be presumed that such writers assume that former civilisations were founded on some other and better basis. By their fruits shall ye know them, is, however, a saying both old and true, and it certainly cannot be denied that concomitant with the developments which trace their descent in a direct line from the great discoveries of James Watt, there has been a very material raising of ethical and moral standards. It would be impossible for a lady to-day to boast, as did the mother of Charles Wesley, that from one year old her children were taught to fear the rod and to cry quietly. Cruelty to children and cruelty to animals has steadily diminished as the knowledge of science and mechanics has increased. That the result is not merely *post hoc* but is really *propter hoc* is suggested by the circumstance that but little improvement was effected in the average ethical standards of the race for centuries preceding the present era. Indeed, in olden times slavery was a necessary concomitant to civilisation, freedom being then incompatible with progress. Plato, in spite of the importance he attributed to ethics, had to base his ideal New Republic on a foundation of slave labour, to do the heavy and repulsive work. From one point of view the introduction of modern methods of sanitation may, no doubt, be regarded as a materialistic improvement, but the fact that filth has no longer to be handled directly by human labour adds to the dignity of man as man, and the gain is accordingly not merely materialistic. Steam now does the rough work of the world. Time has thereby been gained for education of other than the directly useful type, to which the old time mechanic who could neither read nor write was pretty well confined. Again, the probing of the depths of the stellar universe, and the determination of the distance, composition and size of suns whose light takes thousands of years to reach us has been made possible solely by mechanical improvements, but the enlargement of our ideas as to this wonderful cosmos of which we form part has an intellectual and moral, not a materialistic value.

In his James Watt anniversary lecture, delivered to the Greenock Philosophical Society on Friday last, Sir Wm. J. Pope, F.R.S., remarked that from prehistoric times up to the commencement of this "mechanical" age there had been practically no increase in the speed of intercommunication or in the human command of power. This, no doubt, is substantially correct. Indeed, so far as land transport is concerned, it was, as Sir William stated, less easy in the time of Queen Elizabeth than in that of the Romans. It may, moreover, be added that according to Herodotus, the couriers of the great king must have travelled pretty nearly as rapidly as those of ancient Rome. Sir William further observed that with their ample resources of slave labour the Egyptians, Greeks and Astecs achieved architectural feats beyond the power of Christopher Wren. As it stands, this statement is quite true, but it is perhaps capable of misinterpretation. The restrictions to which Wren was subjected were financial merely. Given the requisite financial resources Wren could undoubtedly have accomplished every feat of these ancient peoples, which now arouses our wonder, and he was, moreover, able to build structures quite beyond the technical abilities of the Egyptian, Greek and Astec architects, who did not understand how to turn an arch.

It is probable that part of the interest excited amongst the public by Einstein's theory arose from an uncomfortable feeling that they were unreasonably ignorant of scientific matters. As one labour leader has observed, science leaves him cold, and such a man must experience a feeling of relief if he be informed by the popular writers of the day that Newton has been entirely discredited, and thus any effort expended in acquiring a knowledge of the laws of motion and their consequences would have been wasted. In fact, this class of writer is somewhat given to assuming that each important scientific advance involves the scrapping of all anterior work. The view is no doubt a comforting one, especially to those who resent the application of scientific methods to the discussion of economic and political problems. It is so much simpler and very much easier to be enthusiastic about a "creed" than about a "policy." The concept of a policy necessarily involves that an alternative and possibly better policy may exist, but a creed admits no rival. The one is contingent; the other absolute. A desire to discredit the methods of science by asserting that every ten years marks a complete scrapping of all ideas and theories previously held is accordingly not unnatural, but as Sir William pointed out in his lecture, such a statement is not in accord with the facts. It would, he observes, be just as reasonable to assert that when Columbus discovered America he ceased to believe in the existence of Europe. Every fruitful theory in science must necessarily have contained an element of truth, and when additional facts necessitate a modification of our views this element of truth is incorporated into the new concept.

The major part of Sir William Pope's address was directed to a discussion of the phenomena of radio-activity, and the light it has thrown on atomic structure. These most interesting and

illuminative observations and views have already been very fully set forth in our reports of the courses of lectures delivered at the Royal Institution by Sir J. J. Thomson, Sir Ernest Rutherford and Professor Fowler and need not therefore be discussed at length here. In one or two instances, however, we are afraid that Professor Pope may have expressed himself less cautiously than is desirable with a mixed audience and that misconceptions may accordingly arise. We would suggest that the statement that the average life of a radio-active element is independent of its physical state requires qualification. Whilst true so far as present experience in our laboratories is concerned, it can hardly hold universally since, as the lecturer himself pointed out, much later on, elements are apparently being formed in the stars. In these if we may imitate Spencerian phraseology, helium and hydrogen in a relatively diffused imperceptible homogeneous state are, it would seem, being built up into relatively less homogeneous structures. It is also perhaps going too far to assert that it is *obvious* that the shell of electrons round an atomic nucleus would collapse unless the electrons were in vigorous motion. This is no doubt one view and a very widely accepted one, but as alternatives have been proposed it can hardly be taken as obvious.

One new suggestion made in the lecture is that the set of elements which make up our solar system represents a small part of a gigantic network of radio-active transformations, a patch which is perpetually changing its position in the network by the disappearance of some, and the appearance of new, elements. The set of terrestrial elements would thus seem to be in a kind of equilibrium with respect to our position in stellar time, and whilst the set may change in kind and in environment on this earth, an identical set of conditions may be becoming established in some other and distant planet. As planets shine by reflected light the spectroscope would give us no indication of the appearance on them of new elements due to a degradation of those known on earth. Otherwise the fact that of the elements known elsewhere only nebulium and coronium have so far failed to be found here might be brought forward as an argument adverse to the interesting hypothesis in question.

COAL PRICES.

PUBLIC interest in the coal trade has been fostered by its somewhat stormy industrial history over recent years. The interest, however, is a genuine one, since coal is our chief raw material, and enters as an important item into practically every industrial activity in which the country is concerned. Even agriculture is interested in coal prices, since they must reflect in railway charges, which have an important bearing on its prosperity. Further, beyond any question of industrial uses, practically every householder is a coal consumer, so that he cannot but be concerned with the conditions which maintain it at a level some 100 per cent. above pre-war prices, when the cost of living generally has fallen to some 80 per cent. above pre-war. This figure of round about 100 per cent. increase refers only to household coal, and somewhat smaller increases are the rule when industrial coal is considered.

There has been a tendency of late to lay much stress on railway rates when the question of the cost of coal has been under consideration. In some spheres of industry this may be a reasonable procedure, but in view of the figures published in the Report of the Advisory Committee for Coal and the Coal Industry, which has recently investigated the question of the price of coal to the consumer, it does not appear that railway rates are the only, or even the chief item in the increase in cost of household coal. For best household coal in Central London the selling price in August, 1922, showed a percentage increase of 97 per cent. over August, 1914. Of the items making up this increase, pit price showed an increase of 122·2 per cent., railway freight 48·8 per cent., wagon hire 100 per cent., other expenses, which cover loading, cartage, sacks, establishment charges, etc., 107·9 per cent. Profit was down by 40·7 per cent. Other qualities of coal do not show quite the same figures, and kitchen nuts, for instance, against an increase in selling price of 72 per cent., show an increase of pit-head price of 68·4 per cent., and of railway freight of 66·7 per cent. Wagon hire and other expenses show the same increases as in the case of best quality coal, and profit shows a decrease of 47·8 per cent. Anything which can be done to bring down railway rates will be to the general advantage, but when an analysis shows that for an increase of 27*s.* per ton for best quality coal in London the pit head increase accounts for 16*s.* 6*d.*, the railway freight for 3*s.* 6*d.*, the wagon hire for 1*s.*, and other expenses, as specified above, for 6*s.* 3*d.*, it will be clear that the railway companies are not the only people who are concerned in the matter.

Before commenting on these figures in any further detail, it will be well to note some of the corresponding figures for industrial coal. In the case of gas works, screened coal supplied in London has increased by from 73 per cent. to 87 per cent., and of unscreened coal by 69 per cent. These increases, and all others given in the report, refer to August last. They may be taken as reasonably accurate for to-day. Coal supplied to gas works in Glasgow has increased in cost by from 56 per cent. to 82 per cent. We quote Glasgow in this case as corresponding figures are given for this city for coal supplied to electricity works, and for general industrial purposes. The figures for electricity works show an increase of from 28 per cent. to 32 per cent., and for industrial coal from 41 per cent. to 70 per cent. Locomotive coal supplied to railway companies shows increases of from 50·31 per cent. to 86·12 per cent. It will not be necessary to deal in detail with the incidence of the various items making up these increases, as all we wish to do at the moment is to make the general position clear. It may be mentioned, however, that in the case of gas coal supplied to London, pit-head prices show increases of from 54 per cent. to 80 per cent., railway rates increases of from 50 per cent. to 55 per cent., and wagon hire increases of 100 per cent. Figures for other items are fairly comparable, and in general it may be said that the percentage increase in railway freight is substantially less than the corresponding increase in other items which go to make up the selling price.

As we suggested at the outset, there has been a general tendency to imply, or even state, that railway charges are responsible for the present cost of coal to the consumer, and as recently as Tuesday last the Mining Association interviewed the railway managers of the country in an endeavour to obtain a further reduction in coal freights. As the figures of the Advisory Committee show, railway rates are not the chief item in the increased cost of coal; none the less, if the railway companies can do anything further to reduce the cost of carriage it will be to the general advantage, and by increasing output should reduce pit-head charges, which would be to the direct advantage of the railways themselves, quite apart from any benefits resulting from improved trade generally. The London and North Western and Lancashire and Yorkshire Railway Companies used 2,113,000 tons of coal in 1921, and any fall in the pit-head price must represent a substantial sum when such figures are in question.

The mentality of the country in its consideration of coal costs must necessarily be influenced by the railway grouping schemes which are now in operation. It was announced at large that the amalgamations would lead to economies and better services all round, and the public naturally looks for some evidence of these things. Actually, little can be expected in the time that has yet been available, but in due course these hopes should meet with some measure of fulfilment. Particularly by the introduction of larger wagons, better handling appliances and heavier trains, it should be possible for the large groups to deal with coal and mineral traffic more economically. On the whole, however, and up to the present, the railway companies have not done badly. As was stated above, best household coal sold in London shows an increase of 122·2 per cent. for pit-head prices, and an increase of 48·2 per cent. for railway freight. For the two trades concerned in these increases, coal mining shows an average wage increase of 42 per cent., and railway service an average wage increase of 100 per cent. In both cases the length of the working day has been reduced. These comparisons suggest that from a managerial standpoint the railways have done better than the mining industry. In the case of the mines, the percentage increase in the cost of the commodity is more than twice that of the percentage wage increase; in the case of the railways it is less than half. These figures for best household coal sold in London are specially favourable to the railways, but the same order of result obtains for other classes of coal and other towns. Even if the percentage increase in charges for railways and mines were similar, they must still be offset against more than double the percentage increase of wages in the case of railways.

One of the arguments put forward by the mining industry in favour of reduced railway rates is that such reduction would increase sales and, leading to a greater output, would enable lower pit-head prices to be quoted. This is a legitimate argument, but it would be well that the mining industry should consider the relative percentage increases in wages and selling costs in the coal trade and on railways, and consider if they cannot also assist towards increased sales by reducing their proportion of total costs. The question of the re-introduction of an eight hours day is, of course, already being canvassed, but something might also be done by the introduction of improved methods and modern machinery. With an impoverished industry this advice is easier to give than take, and progress must necessarily be slow; but ultimate prosperity will not come by a policy of waiting for outsiders to reduce their proportion of total coal costs before doing anything.

The other main item of household coal prices in London is "other expenses," which shows a percentage increase of 107·9 per cent., and represents an increase of 6*s.* 3*d.* a ton on the selling price of coal. The main part of this increase is due to cartage and attendant expenses, although establishment charges are also up by 9½*d.* a ton. This total charge of 6*s.* 3*d.* can only be brought down by various minor savings, which cannot well be specified in detail. As an example, sack charges are up by 166 per cent., and now represent a charge of 4*d.* the ton. Matters of this kind can be adequately discussed only by those directly concerned, but it would appear that a closer approach to the pre-war 1½*d.* a ton should be possible. Cartage costs are conditioned by a rise of 120 per cent. in the wages of carters driving one horse, and a consideration of the legitimacy of such an increase in the present state of the finances of the country would appear reasonable. Coal prices and all other prices are ultimately fixed by the state of the demand. Pit-head prices have been forced down from their once very high level by economic causes, and if the other charges on coal are uneconomically high they too will be forced down in time; but it will be to the benefit of the country, as well as to those closely concerned, if the process can be at all anticipated by such attention to the details of their business that wasteful methods are eliminated.

TRANSATLANTIC RADIOTELEPHONY.

ON Sunday night last, by the courtesy of the Western Electric Company, Limited, we were present at a demonstration of wireless telephony which is likely to be memorable in the history of the art. Stated briefly, it consisted of the transmission of speech from New York to London for a practically continuous period of two hours, the volume and clearness of the tones being excellent, and the atmospherics and other extraneous noises insufficient to interfere seriously with the hearing of the messages. Although there have been a number of instances when amateurs and others have received the radiation of American stations, and have even heard the programme of the New York broadcasting station, these have been more or less of an accidental nature, the reception being patchy, irregular and highly uncertain. Such feats are quite incomparable with the demonstration to which we have referred, when some sixty or more guests assembled at a pre-arranged time and received clearly and punctually to the minute the words of a man speaking into an ordinary telephone receiver in his office in New York. Although it is not literally true to say that during the two hours'

transmission not a single word was lost, yet the reception was so good that the various speeches could have been reported with much greater certainty than the words of an average public speaker, and it was generally remarked by the audience that many an ordinary telephone conversation was much less distinct.

The experimental demonstration to which we have referred was arranged at the New Southgate works of the Western Electric Company, Limited, and was the outcome of investigations which are being carried out by the American Telephone and Telegraph Company and the Radio Corporation of America to determine the commercial possibilities of transatlantic telephony. In the present state of knowledge it is, of course, quite impossible to telephone by means of submarine cable for such a distance as the width of the Atlantic Ocean, and if speech with Canada or the United States is to be generally practicable within the near future, radio-telephony will certainly be the means employed. The first attempts to use radio-telephony over really long distances were made in 1915, when the American Telephone and Telegraph Company, using the United States Navy aerial at Arlington, Virginia, got speech successfully through to Paris, Honolulu and Darien. The success, however, was merely technical, as the thermionic valve was not then available of sufficient power to transmit with certainty over such great distances. The results, however, were sufficiently promising for investigations to be continued, and with the much larger and more efficient apparatus which has since been developed the question has again come into prominence.

In order to make a systematic study of the atmospheric and other conditions which enter so largely into the question of commercial transatlantic radio-communication, Dr. H. W. Nichols, of the Department of Physical Research of the International Western Electric Company, and Mr. H. T. Friis, came over to this country a few weeks ago to collect experimental data upon the strength of received signals under all conditions of time and weather. For speech to be satisfactorily heard it is essential that the speech sounds should have an intensity of about twenty times the atmospheric and other noises which are inseparable from long-distance radio-transmission. The present investigations are therefore taking the form of measurements, both of signal strength and of other noises at frequent intervals over a sufficient length of time to get reliable data for general use. Signal strength is measured in terms of micro-volts per metre in the ether, and is thus independent both of the current in the aerial and of the peculiarities of the latter. Noise is measured in similar terms, the respective measurements being made by slightly different tunings of the measuring apparatus. The observations are plotted on squared paper, and the power required at the sending station to maintain a satisfactory ratio between the useful and useless sounds under all conditions is calculated. The signal strength listened to at New Southgate was from 100 micro-volts to 150 micro-volts per metre.

In the demonstration last Sunday night the speech was sent from the offices of the American Telephone and Telegraph Company at 195, Broadway, New York City, the first speaker being Mr. H. B. Thayer, President of the company, who was followed by Messrs. J. J. Carty and E. H. Gifford, vice-presidents, and other officials of the company. In addition to the formal greetings extracts were read from the New York papers, the weather was discussed, and the unpremeditated speeches and humorous comments gave such an extraordinary air of intimacy to the whole proceedings that it seemed incredible that the speakers were 3,000 miles away on another continent. Among other matters Mr. Gifford read an extract from the charter of the American Telephone and Telegraph Company, granted in 1885, by which the company was empowered to communicate "also by cable and other appropriate means to the rest of the known world as may be desirable"; a clause of which those who drafted the charter nearly forty years ago could never have realised the significance. He also pointed out that, so far as transmission was concerned, he and his friends might equally well have been speaking from San Francisco or from any one of the 14,000,000 telephone stations of the Bell Company in the United States.

The transmission of the speeches from New York to the Radio Corporation aerial at Rocky Point, 70 miles away, was effected by an ordinary land telephone line. The aerial is about a mile and a quarter long, and suspended from 150-ft. cross-arms on six towers 250 ft. in height. The receiving apparatus at New Southgate consisted of a frame aerial, about 5 ft. square, with eight valves for reception and amplification purposes. This was situated in a small wooden hut about 200 yards from the room in which the listeners were seated. Here there were 60 sets of head-telephone receivers connected in parallel for the use of the guests, and, alternatively, to these a loud-speaking telephone was used for a part of the demonstration. A frame aerial was employed because the primary object of the installation was to make scientific measurements of signal strength, and the constants of such an aerial can be very exactly known. Moreover, it possesses the property of directiveness, for when set with its plane in the direction of New York it is unresponsive to signals and other electrical disturbances which traverse it at right angles to that direction. The time selected for the commencement of the test was 2 a.m. Greenwich time, which corresponds to 9 p.m. at New York. Radio-transmission, as is well known, is much surer during the hours of darkness, and night-time was therefore chosen in order to avoid any chance of disappointment to the guests, but we understand that previous tests have shown that the apparatus employed is able to maintain satisfactory telephonic communication for 14 hours out of the 24. It is only between the hours of 1 p.m. and 11 p.m. Greenwich time at this period of the year that telephony is unsatisfactory, although signals can be received at all hours of the day.

The wave length employed in the experiments was 5,000 m. This is ten times or more that which is used in ordinary broadcasting, and about double that on which the well-known Paris time signals are sent out. Comparatively long waves are necessary for long-distance transmission, because their absorption is much less than that of short waves. The transatlantic system, however, differs from ordinary radio-telephony in much more than the wave-length alone. All telephony requires a "spectrum band" of about 3,000 cycles per second if speech is to be satisfactorily reproduced. In ordinary transmission not only is the essential modulated component of the wave sent out, but in addition an equal band is sent which is an exact duplicate of the former except that it contains no elements of the signal. For the transatlantic work this useless half of the band is suppressed, with the result that the same intelligibility of signal is received with the expenditure of less than one-third the power which would otherwise be required at the transmitting station. Actually, on Sunday night about 60 kw. was put into the aerial at Rocky Point, whereas more than 200 kw. would have been necessary in the ordinary way. We may mention that the equipment in use was actually capable of supplying 200 kw. to the aerial, which would be the equivalent of something like 600 kw. on a system transmitting the complete wave. The suppression of the carrier wave during transmission makes it necessary to reinstate such a wave at the receiving end, but this can be done by means of a very small valve using a negligible amount of power. Besides the economy of power which results from using a single side-band for transmission, the system has the further great advantage of not monopolising so much of the ether. The range of frequency utilised on Sunday night was from 56,000 cycles to 59,000 cycles only, and as there are only a limited number of frequencies which are practically available, any system which confines itself to half the number which would otherwise be necessary thereby doubles the amount of conversation which can be carried on at any given time without interference.

We have already sufficiently indicated the complete success of the experiments which formed the motive of the gathering, but almost equally striking was the remarkable cable work carried out simultaneously by the Western Union Telegraph Company. As speech was possible in one direction only, New Southgate had to communicate with Broadway by means of cable messages. To facilitate this, special connections were arranged, and within a minute or so of a cable message being written by the sender it was in the hands of the party at the other end. This feat was repeated many times during the evening, cables passing with equal facility in both directions. The organisation of the demonstration on this side of the Atlantic was carried out by Mr. Frank Gill, Pres.Inst.E.E., the European chief engineer of the International Western Electric Company, who entertained the guests beforehand at the Savoy Hotel. The importance with which the experiments were regarded is indicated by the composition of the party, who stayed up all night to witness them. The British Post Office was represented by Sir Evelyn Murray, Secretary to the Department, Major T. F. Purves, Engineer-in-Chief, Mr. Dalzell, Director of Telegraphs and Telephones, and Mr. H. L. Shaughnessy. The Admiralty and the Air Ministry also sent official representatives. Among other guests were Mr. O. B. Harriman, Secretary to the U.S.A. Embassy, Senator Marconi, Mr. Godfrey Isaacs, General Manager of the Marconi Company, Mr. S. I. Goddard, Vice-President of the Western Union Telegraph Company, and Mr. F. W. Wilkins, Vice-President of the Western Electric Company.

INTERNAL-COMBUSTION ENGINES FOR MARINE PROPULSION.

WITH a view to providing information for a discussion on the application of internal-combustion engines to marine propulsion, the North-East Coast Institution of Engineers and Shipbuilders adopted the novel course of asking a number of firms to submit the schemes they would propose for the case of a certain vessel. Drawings of this proposed vessel were submitted to each organisation, accompanied by a diagram showing the estimated least brake horse-power at different speeds of rotation of the propeller to drive the boat at $10\frac{3}{4}$ knots during a 4 hours' trial. The figures used in the preparation of this diagram were based on the experimental data for four-bladed propellers, obtained in tests by R. E. Froude. The firms approached were requested to give the following information:—1. Total brake horse-power of the propelling engines. 2. Overload obtainable in brake horse-power over the trial requirements. 3. Mechanical efficiency, with information relating to the basis on which the figure was obtained. 4. Consumption of fuel per brake horse-power when the ship is propelled at the designed speed: (*a*) for main engines only; (*b*) for all purposes. 5. The brand of fuel assumed and its calorific value. 6. The total weight of the main propelling engines and the auxiliaries in the engine room. 7. Cost of running per ton-mile.

It was thought by the organisers that it was not desirable to specify the sea-speed of the boat when fully laden because so many indefinite conditions not connected with the performance of the engine are involved. All that was considered advisable was to define the practical efficiency of the engine by the provision of information on the brake horse-power necessary to enable a speed of $10\frac{3}{4}$ knots to be maintained during a 4 hours' trial and what part of this could be maintained on a 3,000-mile run under ordinary sea conditions. The space available for the machinery was shown on the drawing, but no limit was imposed on any designer regarding the length of the machinery space he might use, but the difference between the standard and that used was asked for, together with the volume in cubic feet added to or taken away from the cargo space. The cost per ton-mile was expected to be that only of the fuel and lubricating oil, but contributors were allowed the freedom of specifying an estimate of the total average cost per ton-mile of carrying cargo in the ship, if the assumptions made were specified.

Schemes were submitted by seven firms and these were presented to the members of the Institution on Friday, January 12, and it is proposed to hold a general discussion on them on Friday, January 26.

While the efforts of the organisers of this attempt to provide comparable information about the different types of marine oil engines is one to be

commended it cannot be said that the experiment has so far proved a success, but some of the ambiguity may be removed during the course of the discussion. The lack of comparable information in the schemes submitted seems to be due to two causes, the absence of exact information and stipulations in the proposals put forward by the Institution and the natural desire of many of the firms concerned to provide the various items of information only in such a way as would show their proposals, in what they considered the best light. The original scheme was so stated as to make it necessary for at least one firm to seek further enlightenment before submitting proposals.

The replies provided in answer to the request for information regarding the mechanical efficiency seemed to indicate the differing personalities of the contributors, perhaps more than anything else. The values varied between 73 per cent. and 88 per cent. Information was sought by the organisers of the scheme on the method adopted in deducing these values, but what was provided was not always so definite as to make the large differences in the figures clearly understandable.

The variation in fuel consumption for all purposes showed the range as from 7·4 tons to 10·1 tons per day of 24 hours and the addition over that used by the engines only, to meet " all purposes " showed a variation from 2·5 per cent. to 39 per cent.

The minimum value of the total weight of the propelling engines and the auxiliaries in the engine room was 375 tons, while the maximum was 550 tons, or 47 per cent. greater.

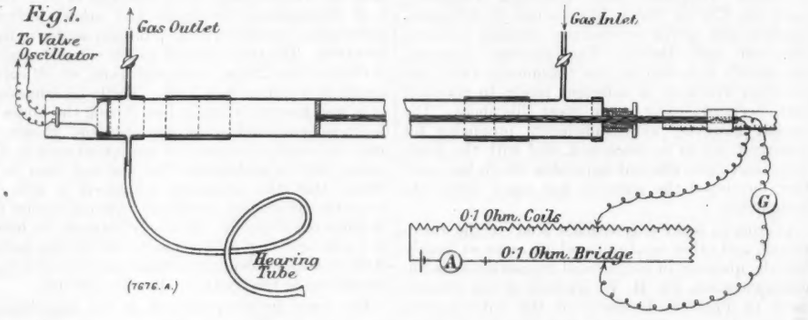
If a fuel oil of the Diesel type and another of the boiler-fuel type had been specified for use and their supposed calorific values, specific gravities, impurities and assumed prices had been given as well as the cost per gallon of the lubricating oil supposed to be available, and if the firms approached had adhered to the use of them, the comparison of costs per ton-mile of running would have been easier of accomplishment. Another factor that might have been asked for is the addition to be made to the fuel and lubrication costs, for the salaries of the engine-room *personnel*. Every firm might have been asked to furnish a statement not only of the number of men required, but also of their class or type and the wages considered reasonable, on which the deductions were made. Due to the use of various prices for fuel oil, which ranged from 77*s.* 6*d.* to 92*s.* 6*d.* per ton for Diesel oil and from 60*s.* to 70*s.* for boiler oil, different prices for lubricating oil, and the inclusion or non-inclusion of the salaries of the engine-room staff, the final results of cost per ton-mile convey little or no information.

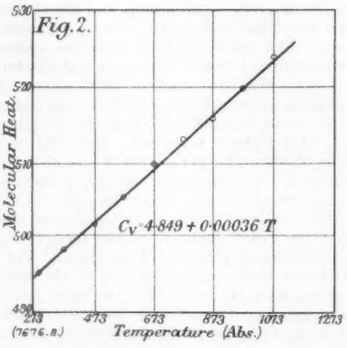
We appreciate the difficulties involved in carrying out the good intentions of the promoters of the proposed discussion. We, also, can understand the position of the contributors to the scheme. If an actual tender were asked for by a shipowner the guaranteed consumptions would be available to him and he would have all the information available to make his decisions, but the provision of such information by all the firms interested in the application of oil engines, to be used for a general discussion and just to provide detailed information regarding costs of running to the general body of engineers, is a different matter. Some information may be given, but it will not always be free from the slight exaggeration natural to all those enthusiasts, whose aim is the introduction of new systems and new methods.

One matter stands out clearly in the suggestions put forward, and that is the variation from the proposed engine-room length which the contributors consider as quite adequate for the accommodation and operation of their plant. The advocates of alterations in the tonnage laws regarding engine-room lengths were given information of a definite character of what space the oil engine builders consider quite ample for all requirements.

VARIATION OF THE SPECIFIC HEAT OF AIR WITH TEMPERATURE.

ALTHOUGH atmospheric air remains the common reference gas for many physical investigations, especially so in thermal work, the value of the specific heat of air at high temperatures belongs to the large number of constants, the exact determination of which is rightly considered as one of the urgent primary problems. In gases we have to distinguish between the specific heat C_p at constant pressure and the specific heat C_v at constant volume. Both may be determined experimentally by various direct methods. In addition, there is the indirect method which determines the ratio C_p/C_v from the velocity of sound in the gas at definite temperatures. In order to deduce from that ratio γ the actual C_p and C_v, we have recourse to an equation of state based upon kinetic and thermodynamic considerations. None of the various equations available are probably more than approximately correct over large ranges of temperature. Those theoretical difficulties are, however, of fundamental nature. Experimentally, all high temperature work with gases causes great difficulties, but we can, at any rate, measure the velocity of sound at a definite temperature, whilst most of the other methods give us merely mean values over relatively large temperature intervals. Hence all the determinations of the specific heat of air, and other gases, since 1900, those of Stevens, of Kalähne, of





Fürstenau, and recently of H. B. Dixon and co-workers (brought before the Royal Society in October, 1921), have essentially been measurements of the velocity of sound.

This applies also to the experiments which Professor J. R. Partington, D.Sc., and Mr. W. G. Shilling, of the East London College, described before the Faraday Society last Monday; the paper was read by Mr. Shilling. The apparatus is illustrated in our diagram, Fig. 1. A large silica tube, 1 m. long, 4 cm. in diameter, is wound with two coils of nichrome wire and lagged with slag wool to heat the air inside the tube up to 1,000 deg. C. Within the tube moves a silica piston, the rod of which is itself a tube, 125 cm. long, 1 cm. diameter, enclosing a thermocouple of platinum/platinum-rhodium; the junction is at the piston, and one of the wires is provided with a fine silica sheath. Outside the tube and the gland packed with asbestos, a square prism of cork is attached to the rod; glass plates are glued to two sides of the cork to act as a guide for the rod when sliding over a scale. The thermocouple wires are joined to a bridge. Into the other end of the tube is fitted the telephone receiver, the diaphragm of which forms the source of sound and closes the tube, being likewise movable as a piston. On the advice of Professor MacGregor Morris a valve oscillator is used to actuate the telephone at a constant frequency; the exact frequency of the note produced is determined by means of a wave-meter, and the frequency is changed with the aid of a variable condenser.

The tube is filled with air—experiments with other gases are to follow—purified and dried with the aid of calcium chloride and phosphorus pentoxide. The gas is preheated to 800 deg. C. or 900 deg. C. in the first instance; with preheating to 400 deg. only moisture films caused complications. Small gas leaks being unavoidable, the gas is kept circulating under small pressure during an experiment, so that a little gas may escape, but no air may rush in. The silica piston need not fit tight, a condition which it would be very difficult to secure with a silica tube. A clearance of nearly $\frac{1}{4}$ in. is, in fact, left, and the piston is packed with asbestos and faced with two mica discs which scrape gently against the tube wall. The telephone being set vibrating the hearing tube of rubber (shown in Fig. 1) is applied to the ear, and the diaphragm is shifted a little to the right or left (not beyond the gas outlet), until the sound maxima are well heard as the silica piston is moved along the tube. The telephone being at the cold end of the tube, outside the furnace, heating and demagnetisation of the steel diaphragms need not be feared; the piston position for maximum sound can be determined within 0·1 mm. The temperature is now raised in steps of 100 deg. C., and from the acoustic wave-length measured and the known frequency of the note, the velocity of the sound can be calculated.

T.	V.	C_p/C_v	C_v	C_p
288	340.65	1.403	4.952	6.945
373	387.16	1.399	4.985	6.974
473	435.44	1.396	5.017	7.004
573	478.80	1.393	5.053	7.039
673	518.30	1.389	5.098	7.084
773	555.10	1.387	5.130	7.115
873	589.35	1.385	5.157	7.142
973	621.53	1.382	5.197	7.182
1,073	651.87	1.379	5.237	7.222

From the apparent velocity V^1 thus obtained the true velocity V is deduced by means of the formula $V^1 = V(1 - c\,k)$, where c is the Kirchhoff-Helmholtz coefficient of correction, required because sound does not travel in narrow tubes with heated walls at the same rate as in the open air, and k is the furnace constant which was determined by the method of Dixon who, in the above-mentioned experiments, used silica coils up to 15 m. in length. From the C_p/C_v obtained, the C_v was finally deduced by means of Berthelot's equation $C_p - C_v = R\,[1 + 27\,\pi\,t^5/16]$, where $\pi = p/p_c$, and $t = T_c/T$, the suffix c marking critical values. Plotting the molecular heat against the absolute temperature, the curve, Fig. 2, was obtained. Above 1,073 deg. absolute (*i.e.*, above 800 deg. C.) the curve bent more steeply upward—as we should expect from Pier's value of the specific heat (determined by explosion tests) at 2,000 deg. But Dr. Partington and Mr. Shilling do not rely upon their values at temperatures above 800 deg. C., because they then found it difficult to secure a sufficiently-long central tube portion of uniform temperature; they are continuing their experiments with longer tubes of nearly 2 m. length. For the range up to 700 deg. C., however, the equation $C_v = 4{,}849 + 0{\cdot}00036\ T$ (in gramme-calories) would hold, and that

formula, which is in good agreement with previous work, together with the concordance of the observations, puts our knowledge of the specific heat of air on a much firmer basis, as Professor A. W. Porter remarked. We summarise the figures found in the table given in the forecasting column in which T is the temperature in degrees Centigrade absolute, and V the velocity of sound in metres per second:

Dr. Partington considered the figures reliable within half a per cent. up to 400 deg. C., and within 1 per cent. or 2 per cent. for the higher temperatures. Then, however, the reliability of the equation of state comes in, and Professor Porter would prefer the equation of Dieterici to that of Berthelot, as covering a wider range of temperature.

NOTES.

VENTILATION OF COAL CARGOES.

A revised set of instructions to surveyors has been issued by the Board of Trade, in Circular 1641, having reference to the surface ventilation of coal cargoes. These instructions cover the size of ventilators, the arrangements for trunks, pipes, &c., the necessity for gastightness of bulkheads, and so on. The principal changes include a new clause as to the arrangement and area of ventilator orifices; the height and thickness of coamings; the methods of securing these to deck, and the points to which attention is to be paid when coal storage space is contiguous to passenger or crew accommodation. The main object, as the title of the instructions implies, is to prevent the accumulation of explosive gas over the surface of coal stored. The regulations are framed with the idea of securing circulation of air over the surface with a view to carrying off such gases. One of the paragraphs expressly prohibits ventilation being carried into a mass of coal. We think this might advisedly be re-drafted in any future edition of the instructions. At present it is worded to read "spontaneous combustion is promoted by the introduction of air into a mass of coal . . ." This statement according to our present knowledge is true in a limited sense only. If stored coal is found to be heating, the best way, as a rule, to preserve it is to reduce its temperature by ventilating the mass thoroughly by turning it over. Supposing coal to be at a temperature as a result of which spontaneous combustion might be anticipated, this may be averted either by the prevention of all access of oxygen, which will render further heating impossible, or the provision of an excess of ventilating air, which will cool the coal down. Between these two extremes there is a range over which the supply of moderate quantities of air will, it is true, tend to promote combustion. On board ship it would not be practically possible we imagine to provide the excess required to effect cooling, and certainly the ventilating cowl would not be effective in this direction. The regulation, therefore, is probably the best possible under the circumstances, though the phraseology may not be quite happily chosen.

THE MECHANICAL SEPARATION OF MATERIALS.

The separation of materials by mechanical means enters into a wide range of industries, but Mr. Cecil Bentham, in his paper read before the Manchester Association of Engineers on Friday last, practically confined his attention to grain and coal. This paper did not, of course, refer to grading so much as to separating out and removing foreign substances, such as other grains, seeds, &c., in the case of wheat, or shale and stone in the case of coal. The case of grain was most fully dealt with and, as is well known, this, as now carried out, involves processes dependent upon various characteristics. Mr. Bentham divided his subject into broad headings according to the feature on which a process depended, such as size, shape, specific gravity, texture, or magnetic properties. As employed by Mr. Bentham, however, the term texture is used to cover a variety of combinations of the first three, and as far as he carries the subject can hardly be considered a class apart. Separation by size is, of course, normally carried out by some form of sieve or screen. Separation by shape has, in the grain industry, resulted in the ingenious indented-cylinder or disc machines, in which foreign grains are picked out of the mass by appropriately shaped pockets. Classification is clearly difficult, for Mr. Bentham places the vertical chutes of a combination of spirals, as applied to grain, in the class which discriminates by shape, whereas when applied to coal, as illustrated on page 359 of ENGINEERING, vol. cxiii, this appliance classifies more by specific gravity and texture than by shape. Again, separating by air currents is brought into the section on separating by size, and is not referred to in connection with specific gravity classification at all, in which section washing processes only are dealt with. This section also might have been rendered a little more complete by some reference to the Wilfley table and to the flotation systems. The paper, however, is an interesting account of the principles employed, mainly in the grain and milling industry, and deals with present-day machines and methods.

THE INSTITUTE OF METALS.

The secretary of this Institute announces that the annual general meeting is to take place in the hall of the Institution of Mechanical Engineers on Wednesday and Thursday, March 7 and 8, commencing on both days at 10.30 a.m., when more papers are expected to be presented for reading and discussion than at the Swansea meeting last autumn, at which 15 papers—a record total—were taken. The council are arranging a special ballot for the election of members in time for the March meeting, this ballot taking place on February 22. Candidates who are elected as a result of this ballot will have the privilege of membership not only for the usual 12 months, but for the extended period ending June 30, 1924, during which they will receive three bound volumes of the proceedings instead of the usual two. The forthcoming volume is expected to be of record size since, in addition to the papers and discussions of the Swansea meeting, it will include Sir Ernest Rutherford's May lecture on "The Relation of the Elements," and Dr. Hutton's autumn lecture on "The Science of Human Effort (Motion Study and Vocational Training)," besides 300 pages of abstracts from metallurgical papers published throughout the world. A proof that the work of the Institute is being greatly appreciated abroad is afforded by the fact that applications for membership are now coming in freely from foreign countries, more freely even than present-day applications from this country, and the council express the hope that British membership will not only keep up to its high level but will increase freely also. With a view to aid in developing membership overseas, the council have, further, appointed a British Empire Committee, on which the Overseas Dominions are represented by distinguished metallurgists in London having an intimate knowledge of overseas conditions. The Institute's local section in Swansea, to which we referred in past issues, is now duly formed, and besides the one in Swansea, there are now local sections in Birmingham, London, Glasgow, Newcastle-on-Tyne and Sheffield. An idea of the work carried out at these local sections can be gathered from the reports we have given in recent issues of the meetings of the one in Sheffield. The activity displayed by the secretary of the Institute, the excellence of the papers presented, the care with which they are edited, and the aid which these papers and the discussions thereon are giving the non-ferrous metals industry, are contributing to place the Institute, though of comparatively very recent formation, among the leading British scientific societies.

PRIZES AWARDED BY THE SCOTTISH SOCIETY OF ARTS.—The committee appointed by the Royal Scottish Society of Arts to award prizes for communications read or reported on during the session 1921–22 report that it has awarded the following prizes: To A. P. Laurie, M.A., D.Sc., F.R.S.E., for his paper on "The 'Pier Method' of Building Brick Walls" (No. 4,984), a Keith prize, value seven sovereigns. To Andrew H. Baird, F.R.P.S., for his paper on "The Universal Bosshead Clamp" (No. 4,985), a Makdougall-Brisbane medal. To Dawson Turner, M.D., F.R.S.E., and D. M. R. Crombie, for their paper on "An Investigation of the Ionised Atmosphere around Flames by Means of an Electrified Pith Ball" (No. 4,990), each a Makdougall-Brisbane medal. To Henry Briggs, Ph.D., D.Sc., A.R.S.M., M.I.M.E., for his paper on "A New Mine Rescue Apparatus" (No. 4,991), a Keith prize, value seven sovereigns. To Basil A. Pilkington, F.R.S.E., for his paper on "A Readily-Destructible Material suitable for the Conveyance of Confidential Communications" (No. 4,993), a Hepburn medal.

LITERATURE.

Steel Thermal Treatment. By JOHN W. URQUHART. London: Crosby Lockwood and Son. [Price 35s. net.]

THIS is essentially a book for practical steel users, and, as the author states in his preface "is an attempt to co-ordinate the work of the laboratory with that of an engineer's hardening department." He does not attempt to enter into the physical chemistry of steel, which he says in his first chapter is outside the scope of the present work. He gives, therefore, no thermal-equilibrium diagrams, does not speak of α, β and γ irons, and all his definitions are such as will be readily understood by practical men who might otherwise have been alienated by the highly scientific phraseology often encountered in works of this type.

After briefly touching upon the great advance made in the production of alloy steels during the past twenty years, the author devotes his first chapter to a brief review of the nature, heat treatment, and ultimate strength of the plain carbon and alloy steels used in present-day industry. He also gives us a fairly complete glossary of terms used by steel men, descriptive of particular steels or their condition, the language used is well chosen and is distinctly of a non-theoretical nature.

The second chapter is headed "Physical Characteristics of Steel," and the importance of mechanical testing after heat-treatment is fully brought out. The meaning and limits of all mechanical tests used by engineers are discussed and some useful formulæ and tables are given. The Brinell and Scleroscope methods are minutely described, and the relation existing between the Brinell hardness number and the scleroscope value is fully shown. The author then deals with the heat treatment of carbon and alloy steels and devotes some space to the theory and conditions of practice of annealing, quenching and tempering. He describes the formation and influence of martensite, troostite and sorbite. He then considers the hardness imparted by correct heat treatment. His remarks on cutting hardness, and especially the relationship existing between the tool and the material to be cut are most instructive. Hardness standards adopted by automobile engineers are given in detail, and are followed by useful tables showing the effect of annealing on the physical properties and structure of medium and high carbon steels. A series of photo-micrographs, some notes on the magnetic properties of steel and its dimensional changes during the hardening process close a long and very important chapter. In short it is a rapid review of the whole subject under consideration. Each section is dealt with in detail in subsequent chapters.

At the outset of the chapter on "Elementary Thermal Processes," the author condemns the term heat-treatment as being far too wide and vague. For convenience he divides the procedure (as applied to constructional rather than tool steel), into the following five sections: (1) Normalising; (2) Softening or Annealing; (3) Hardening or Stiffening, with Toughening; (4) Tempering; (5) Intensified Treatment; each being defined and its importance explained. He then briefly reviews the three leading methods of obtaining the all-important "Ar." points—(1) The use of a pyrometer; (2) the use of the magnetic test; and (3) the visual or optical method. The advantages and disadvantages of each method are given, the whole question being considered more in detail in the special chapter on "Workshop Heat Measurement."

The importance of the rate of cooling and the production of martensite, troostite and sorbite are explained and illustrated by means of photo-micrographs. Typical thermal processes for low carbon steels and some nickel steels are given. The necessity of taking precautions in heat-treating nickel steels due to their peculiar behaviour during the critical range is touched upon by the author.

The next three chapters, (*a*) The Furnace (in connection with steel thermal treatment), (*b*) Electric Equipment, and (*c*) Workshop Heat Measurement, are capital, and we congratulate the author on his clear and lucid exposition of each subject.

Solid fuel furnaces are briefly reviewed, the author contending that, although used successfully, they

demand the services of experienced men to run them in connection with steel thermal treatment, he maintains that gas furnaces are much more easily controlled and, in his opinion, prove cheaper, in the long run, than coal or coke furnaces. He further states that we have, in this country, surpassed all nations in the invention and development of gas furnaces. The relative lower cost of producer gas as compared with town gas is fully discussed, and an illustration and short description of a satisfactory type of producer given. Various gas furnaces, chiefly of a large type, are described in detail, and space is devoted to such important subjects as efficiency, accurate temperature control, and nature of flooring. The ordinary type of gas muffle is condemned as unsatisfactory, and alternative small furnaces which are much more effective are described. The chapter closes with tables of gas consumption, valuable hints on the working of furnaces, and other useful data.

The author's review on the use of small, medium and large electric furnaces occupies 17 pages, it is brief and yet detailed, and from beginning to end he emphasises the enormous advantages secured by the adoption of such furnaces. Hence on pages 129 and 130—"There is a field for electric heating—a field where its higher cost is, comparatively, of no account. The question of competition between electricity and fuels does not arise at all when the employment of electricity will lead to a result which gas or oil cannot produce." The author's opinion that the resistance furnace is the electric furnace, *par excellence*, for steel thermal treatment will be shared by all familiar with the subject. He describes "nichrome" wire and ribbon and other heating elements. As an example of large installation, he mentions a ribbon-wound furnace installed by the Electric Furnace Construction Company, having internal dimensions 36 ft. deep by 6 ft. diameter and having capacity for four 6 in. naval gun forgings. The carbon resister types of furnaces are dealt with separately and are divided into five distinct classes: (1) Hearth type, (2) continuous pusher type, (3) car type, (4) automatic continuous heat-treating sets, and (5) continuous recuperative pusher type for large tonnage. The advantages of electric furnaces are well summed up by Mr. D. D. Miller, whom the author quotes as saying "Some of the advantages of an electric furnace are elimination of oxidation; uniformity of temperature; accuracy of control, enabling work to be heated to within 10 deg. F.; certainty of duplication; clean work; saving in labour and material, since it is not necessary to remove scale; and absence of smoke, fumes and noise."

In dealing with the use of a pyrometer for measuring temperature in the hardening shop, the author insists upon frequent standardisation of the instrument. He also points out that all temperature measurements should be correlated with time measurements. He reviews the various types of pyrometers on the market and states the advantages and defects of each. His description of the optical pyrometers and recorders now turned out by the Cambridge Scientific Instrument Company, and by the Shore Company, in New York, are very complete and well illustrated.

Going on to the question of carburising materials the author is not in favour of purchasing proprietary case-hardening compounds. He maintains that the price demanded is often excessive (for what are often common materials), and urges the case-hardener to work only with substances of known composition. He gives an excellent review of the leading carburising substances in general use, such as wood charcoal, animal charcoal, barium carbonate, &c., &c. He then proceeds to give a thorough and minute description of all methods of case-carburising and case-hardening, and valuable advice is given on all branches of the subject. The chapter is illustrated by micro-photographs. An important process, which has come into prominence of late, viz., the carburising of nickel steel, is well described. The value of the work done by Professor Giolitti (Genoa), and others on "gas carburising," is highly appreciated by the author, who foresees a great future in store for this process.

A chapter devoted to the detailed study of quenching follows, and although somewhat involved it is replete with information. The author gives us some sound advice regarding the double-quenching of case-hardened parts, and this all-important subject, as applied to case-hardened nickel and alloy steels is again dealt with in the following chapter. A list of quenching media in general use is given, and the place and value of each discussed. Consideration of the author's practical hints on quenching reveal the fact that he is giving his readers the benefit of years of experience. Engineers will be interested in the author's admirable remarks on locomotive axle hardening and the spray system of quenching for heavy sections.

Chapter X is entitled "Thermal Treatment Processes," and is a sequel to Chapter III, "Elementary Thermal Processes." The correct heat treatment of plain nickel and carburised nickel steels is described in detail. The value, properties and peculiarities of nickel-chrome, chrome vanadium and other high-grade steels are discussed. The case carburising and subsequent heat-treatment of alloy steels of this type is described at length.

When considering manganese steels the author mentions their great usefulness during the war for making trench helmets, sprockets and gears for tanks—which could not be perforated or otherwise destroyed by shrapnel bullets—and non-magnetic submarine mines. In the matter of manganese steels for these war-time and other specialities, the names of British firms—Messrs. Hadfields, Edgar Allen, and others—will suggest themselves immediately to the reader. The chapter closes with some brief remarks on silicon and silico-manganese steels, and a detailed list of heat-treatment processes covering most grades and categories of steel used in the motor car and kindred industries. This list, we are told, has been approved by the steel division of the Society of Automobile Engineers, U.S.A., 1912, and has been extensively used in Europe since that date.

Chapter XI, entitled "Tools and their Steels," is, in some respects, the most important in the whole work. Spread over some 34 pages we find it so complete and thorough that it is almost impossible to deal adequately with it in the small space at our disposal. Forging temperature, treatment on the anvil, the quenching and tempering of turning, planing, chiselling and rivet-setting tools, drills of all descriptions, milling cutters, screw-slot cutters, reamers, &c., &c., are described in a lucid and masterly fashion. The author condemns a great number of the old-fashioned processes used in various hardening shops as erratic and, in some cases, dangerous to the steel under treatment. All far-sighted manufacturers of engineer's tools will absolutely agree with him that modern methods based upon scientific lines will inevitably lead to concordant and reliable results. We would like to draw the special attention of all manufacturers and engineers to the author's excellent remarks on the involved question of the hardening and tempering of springs, a subject dealt with at some length in this chapter.

The discussion of tools and their steels, in a general way, naturally leads on to the more detailed consideration of press tools and high-speed tools. In the former case the material used for dies and its subsequent carburisation and heat-treatment is fully described. The author deals mainly with carbon steel press tools, but he draws attention to the increasing importance of alloy steel dies. Chrome-vanadium steel has many advantages, and is particularly adapted to heavy press work and also for the hardest of all steel tool work, namely, drop-forging dies.

The revolution in mechanical engineering practice caused by Mushet's discovery of the red-hardness of tungsten steel is touched upon by way of preface in the chapter on high-speed tools. The author demonstrates that increasing hardness is obtained by raising the temperature of the tool from 1,000 deg. to 1,200 deg. F., the Brinell number for the former being 540 and for the latter 630. The significance of these figures will be fully realised when it is remembered that at 1,200 deg. F. the tool steel is at a blood-red heat. The author points out that a plain tungsten steel, while effective in getting through the work, leaves it lacking in finish and recommends as a remedy the addition of chromium and vanadium (especially the former). These metals have the effect of imparting that "very fine edge which the later high-speed steels can maintain under adverse conditions." Analyses are given of various high-speed steels on the market, these include the British "Novo," the French "Bedel" and American and German varieties. When giving instructions on the heat-treatment of high-speed steels the author quotes long passages from a paper by Mr. F. W. Taylor, who, in conjunction with Mr. White, conducted a series of valuable investigations on the subject at the Bethlehem Steel Company's works. The tendency of high-speed steels to self-fracture is emphasised by the author, who considers that precautions against violent changes of temperature when forging or grinding are absolutely essential.

Discussing the possibility of nitrogen being the softening agent, in tool steel under certain conditions, the author says (page 314), "At the high temperatures used, it would appear that the nitrogen of the air, combining with the carbon, and so forming methane, would account for the softness of the surface." This is evidently an oversight, the gas the author has in mind is, almost certainly, cyanogen $(CN)_2$; methane, CH_4, contains no nitrogen.

The value and possibilities of stainless steel are well set out in the closing chapter. The author describes difficulties encountered and the peculiar behaviour of the material under various conditions, and gives a large amount of useful data on the subject.

The whole work is very complete and modern and, throughout, the author has striven to explain intricate scientific processes in the simplest possible language. We would like to point out, in this connection, that we consider it almost impossible for anyone to thoroughly understand the nature of such micro-constituents of steel as austenite, martensite, troostite, sorbite and pearlite, without being familiar with the thermal equilibrium diagram of the system iron-iron carbide. Again, a good, working knowledge of thermal-equilibrium diagrams greatly simplifies, in our opinion, the study of correct annealing, quenching and tempering temperatures, for various grades of steel, and, to a large extent, obviates the necessity of using complicated tables. We feel we must congratulate the author on what we might describe as a *tour de force* on his part. He has written a work on the heat-treatment of steel without introducing those complex subjects—thermo-chemistry and physical chemistry, and, we are bound to say, the book will prove a success in many respects.

Seagoing and Other Concrete Ships. By N. K. FOUGNER, M. Am. Soc. C.E., Assoc. Inst. N.A., of Christiania. London: Henry Frowde and Hodder and Stoughton, 1922. [Price 21*s.* net.]

THE Oxford Technical Publications have added a notable contribution to the annals of shipbuilding at the hands of one of the most ardent pioneers of the concrete ship era. During the mid-war period when an enterprising coterie of shipbuilders turned their attention to the question of constructing moderate-sized cargo ships of reinforced concrete, whereby an economy in the use of steel in its period of stringency, and later the Government Ministry of Shipping, from a like motive, to create new tonnage for cargo-carrying economically, rapidly and by the employment of labour largely drawn from the then stagnant building trades, their confidence was considerably strengthened by the example set before them by the building of the first motor-driven concrete vessel, Namsenfjord, at the Fougner Shipbuilding Company's yard at Moss, near Christiania, Norway. Consequently, it will be of special interest to those identified with the concrete shipbuilding in this country to read the history of the early beginnings of the collateral constructions in Norway as developed by the author of the present work, and of the more extensive activities into which he entered later in connection with the programme embarked upon by the United States Shipping Board in America.

The object of the treatise which the author has kept in view has been to establish the status of the concrete ship and to present a record of the principal ships actually built. After devoting the first seven chapters, illustrated by numerous photographs and useful working details, to the consideration of

typical concrete craft built in Norway and the United States of America, the remaining six chapters are chiefly concerned with an examination of comparative costs of ships built and with the technical questions relating to the design and construction. The book includes an appendix, giving in neat form the complete set of strength calculations which were actually made in the office for the 1,000-ton deadweight cargo-ship, Askelad, and in these are to be seen, for comparison, the calculated strength of equivalent beams and framing for a steel ship of the same dimensions.

The author has throughout his chapters dealt with the special features relating to concrete shipbuilding in a clear and agreeable method of reasoning, and his conclusions incline to suggest that for cargo boats ranging between 2,000 tons and 6,000 tons deadweight, and also for constructions such as floating docks, concrete may yet come to hold its own against its present rival in mild steel. Certainly some of the recent constructions of floating docks in Trieste and Germany give point to this opinion, and the chances of it becoming realised may depend to a great extent if certain desirable improvements which the writer anticipates may be realised by the production of a lighter and more elastic or ductile quality of shipbuilding concrete.

The chapter dealing with the theory of the design of beam reinforcement is set out clearly and simply explained, although it would have been an advantage if the standard notations had been more closely adhered to instead of, for instance, expressing the modular ratio by n and at the same time in the appendix using the usual expression m. Similarly the expressions for steel ratio, lever arm and shear stress are given unusual letters which represent in some of the formulæ terms which are not always recognisable until the context has been referred to.

Perhaps one of the best chapters in the book is that dealing with the subject of shipbuilding concrete, and in it is to be found much useful information relating to the preparation of the most appropriate mixtures for the purpose. Informative tables of test results add to some excellent advice on the preparation of the mixtures.

The concluding chapter reviews in a series of reasoned comments some special methods of construction and particular ships, amongst which are mentioned the very successful instance of s.s. Armistice, constructed in this country by the Ferro-Concrete Ship Construction Company, at Barrow-in-Furness. The latter vessel, if not so lightly constructed as the author would have expected, has nevertheless proved herself a fine example of good substantial construction and given most satisfactory results in her regular sea service. After commenting on the features of the several typical ships, the author concludes with some general recommendations based on the results of his own experience and observations which point the trend of future developments.

When circumstances, or even academic interest, causes the naval architect's attention again to be directed to the study of reinforced concrete as applied to floating structures or ships, he will find in the present volume a substantial guide to a clear understanding of the essential principles of the art. The steel ship will, in the main, stand firmly secure in the confidence which a decade of effort has conferred, and a decided preference may be retained for a material which can pass its mechanical tests almost without sensible variation, as well as be able to withstand rough usage and not suffer from abrasion through over-delicacy, whilst fittings, castings and similar fixtures can be incorporated with the steel hulls cheaply and efficiently, and in a country where shipbuilding is strongly established, questions of labour organisation with all the tedium of demarcations of work, must not be overlooked. Yet, given certain advancements in the art of producing a light-weight concrete which can be worked safely to higher stresses than are considered permissible at present, it may be conceded that concrete afloat may legitimately aspire to a larger share of usefulness and repay its careful study. At any rate, the problem has been concisely presented in this book alike for the shipowner and the shipbuilder, and, although it would be too much to expect any immediate development, the author may justly be entitled to some satisfaction for having so well succeeded in establishing within its limitations the case for the sea-going concrete ship.

BOOKS RECEIVED.

Mechanical Engineering Detail Tables. By J. R. ROSS. London: Sir Isaac Pitman and Sons, Limited. [Price 7*s.* 6*d.* net.]

Meteorological Office. Air Ministry. Report on the Distribution of Rain in Space and Time over the British Isles, 1921. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 12*s.* 11*d.* post free.]

Electricity in Agriculture. By ARTHUR H. ALLEN, M.Inst.E.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

The Practical Engineer Mechanical Pocket Book and Diary, 1923. Edited by ERNEST G. BECK, Wh.Ex. Assoc.M.Inst.C.E. London: Henry Frowde and Hodder and Stoughton. [Price 2*s.* 6*d.* net.]

The Diesel Engine. By A. ORTON. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

United States Bureau of Labour Statistics. Bulletin No. 305. *Wages and Hours of Labour in the Iron and Steel Industry: 1907 to 1920.* Washington: Government Printing Office. [Price 15 cents.]

United States Bureau of Mines. Bulletin No. 188. *Lessons from the Granite Mountain Shaft Fire Butte.* By DANIEL HARRINGTON. [Price 15 cents.] No. 193. *Analyses of Mine and Car Samples of Coal collected in the Fiscal Years* 1916 *to* 1919. By ARNO C. FIELDNER and others. [Price 35 cents.] No. 209. *Fusibility of Ash from Coals of the United States.* By W. A. SELVIG and A. C. FIELDNER. [Price 15 cents.] Technical Paper No. 306. *Operation and Maintenance of Electrical Equipment approved for Permissibility by the Bureau of Mines.* By L. C. ILSLEY. [Price 5 cents.] Washington: Government Printing Office.

United States Geological Survey. Bulletin No. 722. *Mineral Resources of Alaska, Report on Progress of Investigations in* 1920. By A. H. BROOKS and others. No. 724. *Nitrate Deposits in the Amargosa Region, South-Eastern California.* By L. F. NOBLE and others. [Price 35 cents.] Water Supply Paper No. 463. *Surface Water Supply of the United States,* 1917. Part XII. *North Pacific Drainage Basins.* B. *Snake River Basin.* [Price 15 cents.] No. 478. 1918. Part VIII. *Western Gulf of Mexico Basins.* [Price 10 cents.] No. 484. 1918. Part XII. *North Pacific Slope Drainage Basins.* C. *Lower Columbia River Basin and Pacific Slope Drainage Basins in Oregon.* NATHAN C. GROVER, Chief Hydraulic Engineer. [Price 15 cents.] Washington: Government Printing Office.

The Observer, 1791–1921. *A Short Record of One Hundred and Thirty Years.* London: Offices of the *Observer.*

Brassey's Naval and Shipping Annual, 1923. Edited by Sir ALEXANDER RICHARDSON, M.P., and ARCHIBALD HURD. London: William Clowes and Sons, Limited. [Price 25*s.* net.]

Pratique du Calcul du Béton Armé. Part I. By G. MAGNEL. Gand: Van Rysselbergh and Rombaut. [Price 30 francs.]

The Electrical Engineer's Year Book and Diary, 1923. Edited by J. H. JOHNSON, M.I.E.E. London: S. Davis and Co. [Price 21*s.* post free.]

The Textile Recorder Year Book, 1923. Compiled and Edited by FRANK NASMITH. Manchester and London: John Heywood, Limited. [Price 7*s.* 6*d.* net.]

Civil Engineering Geology. By CYRIL S. FOX, B.Sc., M.I.M.E., F.G.S. London: Crosby, Lockwood and Son. [Price 18*s.* net.]

The Business Directory, London, Provincial and Foreign Trade Guide, 1923. London: J. S. C. Morris. [Price 2*l.* net.]

The Racing Eight. Notes on Its Design and Propulsion. By W. B. COVENTRY. Cambridge: W. Heffer and Sons, Limited. [Price 3*s.* 6*d.* net.]

Cements and Artificial Stone. A Descriptive Catalogue of the Specimens in the Sedgwick Museum, Cambridge. By the late JOHN WATSON, M.A., F.G.S. Edited by R. H. RASTALL, Sc.D., M.Inst.M.M. Cambridge: W. Heffer and Sons, Limited. [Price 6*s.* net.]

The Philosophy of Management. By OLIVER SHELDON, B.A. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

Metal Turning Made Easy. London: Cassell and Co., Limited. [Price 1*s.* 6*d.* net.]

Willing's Press Guide and Advertisers' Directory and Handbook, 1923. London: James Willing, Limited. [Price 2*s.* 6*d.* net.]

Annuaire pour L'an 1923. *Public par le Bureau des Longitudes.* Paris: Gauthier-Villars et Cie. [Price 6.50 francs.]

A List of English Clubs in all Parts of the World, 1923. By E. C. AUSTEN-LEIGH, M.A. London: Spottiswoode, Ballantyne and Co., Limited. [Price 7*s.* 6*d.* net.]

Elasticity and Strength of Materials used in Engineering Construction. Section I. By C. A. P. TURNER, Minneapolis: C. A. P. Turner. [Price 5 dols.]

The Journal of the Iron and Steel Institute. Vol. CVI, 1922. Edited by GEORGE C. LLOYD. London: Offices of the Institute.

PERSONAL.—Messrs. Thomas H. Howell, Limited, iron and steel merchants, of Newport, Mon., have opened an office at 65, Fenchurch-street, E.C. 3.—Mr. William H. Hutchinson has joined the Board of Sir William Arrol and Co., Limited. He was a partner in the firm of Messrs. Baldry, Yerburgh and Hutchinson, general contractors, of Westminster.

THE LATE MR. AMBROSE FIRTH.

WE regret to have to announce the death of Mr. Ambrose Firth, which occurred at Bournemouth on Thursday, the 11th inst. Mr. Firth was chairman of the Brightside Foundry and Engineering Company, Limited. He was born at Grimesthorpe in 1845, and early in life was associated with Mr. John Stanley at the Foundry, Brightside, Sheffield. He started business on his own account in 1865 as an ironfounder in a small foundry near the River Don, on part of the site now occupied by the works of Messrs. Vickers, Limited. He moved later to larger premises in Newhall-road, where he started, among other foundry work, the casting of heavy ingot moulds and large rolls for the heavy steel trades, a branch of manufacture which gradually developed to the casting of moulds exceeding 110 tons in weight. He increased his works and plant at Newhall-road; he also acquired at different times other businesses, each having its special product, and amalgamated these into one concern. Thus the firm has become not only the largest iron founders and makers of steel works' plant, but is known also for its hydraulic machinery, brick and tile presses, colliery plant, machinery for heating and ventilation, &c., having branch works and offices in London, Manchester, Liverpool, Birmingham, Cardiff and Newcastle.

The works which Mr. Firth purchased at various periods and incorporated with his own included J. C. and J. S. Ellis, heating and ventilating engineers; the heating business of J. F. Hill; Clayton, Howlett and Co., brick-making machinery manufacturers; Hunter and Middleton, manufacturers of similar machinery; Walker, Heaton and Co., ironfounders and engineers; John Robinson (Royd's Foundry), Moorwoods, Limited, founders and engineers; Pullan and Mann, manufacturers of brick-making machinery.

Until quite recently, when his health broke down, Mr. Firth took a keen interest in all the activities of his firm, the Brightside Foundry and Engineering Company, and it is largely due to his sound judgment and wise direction that it has progressed in so remarkable a manner, and has acquired a world-wide reputation. He had a great faculty for inspiring those in his employment with a desire to give their best services; a proof of his success in this direction is afforded by the fact that the various branch managers are all men who entered the firm in their youth, and one of the present directors joined it as a boy of 15.

Throughout his career Mr. Firth was a man of unimpeachable character, in every way a man who was held in the highest regard by his firm, associates and employees. When residing in Derbyshire, he acted for a time on the Derbyshire County Council, he was also a Justice of the Peace for the county, and a member—at one time chairman—of the Bamford Parish Council. He was, further, a director of Messrs. W. Cooke and Co., Tinsley, chairman of the Hathersage Gas Company, a member of the Institution of Mechanical Engineers, the Iron and Steel Institute, the Sheffield Chamber of Commerce and other bodies. Mr. Firth died at Bournemouth, where he had resided for the last two years for reasons of health. A host of friends in every sphere of life, won by his genial and sympathetic disposition and the genuineness of his character, remain to mourn his decease.

BOILER HOUSE ECONOMY.—Following the report of the Fuel Economy Committee of the Chemistry Section of the British Association in which it was recommended that local education authorities would help fuel economy by the institution of properly-organised courses of instruction for the lower grades of boiler-house workers, the Education Committee of the Sheffield City Council have adopted the scheme proposed by Mr. Chas. F. Wade, A.M.I.Mech.E., A.M.I.E., for the purpose mentioned. The very gratifying results in the number of students obtained is chiefly due to the active support of the Sheffield Chamber of Commerce and other local manufacturers, many of whom have arranged to pay the fees of any of their employees who are attending the course of 12 lectures arranged.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—At a meeting of the Institution, held on the 12th inst., Mr. B. R. Wingfield, when dealing with automatic regulation, gave information which would lead to economy in working and in fuel. After describing various types of regulators, he remarked that he was convinced that overheating would be avoided and that there would be a saving in fuel, to the ultimate benefit of the community, if temperature regulation were made a regular part of every central heating installation, whether large or small. Increased numbers of installations would bring down first costs, and the ill reputation of central heating—as a costly method of warming, which only the wealthy could afford—would disappear. This question of reliably regulated and simple central heating was very important at the present time, when, on account of the difficulty of getting domestic help, the question of labour-saving was a subject of frequent discussion. There was no reason why a carefully-planned hot-water heating installation should materially add to the cost of a five or six-roomed house if the saving in chimneys and fireplaces were taken into account.

THE PASSENGER ACCOMMODATION IN LARGE LINERS.

TO THE EDITOR OF ENGINEERING.

SIR,—The interesting description in your issue of January 5, of the new Cunard liner Samaria, recalls recent letters in *The Times* on the subject of the lack of comfort in the sleeping accommodation on the modern passenger steamer. Space is lavishly devoted to ornately decorated and little-used drawing rooms, while it is next to impossible to book a single-berthed cabin, even at the expense of a considerable surcharge on the already high rates. Surely most travellers would willingly forfeit the so-called luxury of the "eighteenth century" music rooms, &c., in exchange for a decent privacy in their most intimate moments. Even you, Sir, describe the passenger accommodation on the Samaria as a "modern and luxurious hotel," but in what hotel would one be normally expected to sleep with a total stranger? The criterion of comfort on a modern liner should be not the luxurious furnishings of music rooms, but the percentage of single-berth cabins.

Yours truly,
"SYBARITE."

"THE EDUCATION OF ENGINEERS."

TO THE EDITOR OF ENGINEERING.

SIR,—It would seem that your correspondent "A.R.L." has either not read beyond the first paragraph of my article or has missed the whole point of it. To avoid further misunderstanding, please allow me to repeat that my object is not to prevent the study of what "A.R.L." terms "complex" algebra, but only to persuade engineers that there is no "complexity" involved in it.

If "A.R.L." will consider the question for a moment, he cannot fail to be convinced that there is no place whatever in engineering for imaginary quantities as they are used in pure mathematics. Which part or parts of an electric current, or of an aeroplane, can be rendered imaginary by turning them through an angle? Progress will be retarded so long as we delude ourselves in such matters by the use of bad symbolism and vague ideas.

Functions which relate to real things (*i.e.*, all functions usable in engineering) can be treated, whatever their degree, without the aid of "i"; and the lack of clarity in the minds of even pure mathematicians on this point is evidenced by their promiscuous use of the same symbol to convey essentially different meanings. Stated baldly, the symbol "i" as used in the theory of functions, means neither more nor less than that the lengths to which it is attached are to be measured in a direction perpendicular to that for the other lengths; and it has no relation whatever to the square root of minus one. The "imaginary quantity" (as used in pure mathematics) is one of the greatest—as well as one of the most transparent—frauds ever devised to imply an association with supernatural powers where, in fact, nothing beyond simple human reality is concerned. Everything which can be done with the aid of "i" can be done better without it; and in view of the fanatical worship which the imposter receives, it is necessary to speak plainly concerning it. However, the imaginary quantity is but one of many hollow shams which are allowed to mystify those who permit the symbol to eclipse the reality which it is supposed to represent; and until all these shams are exposed, and replaced by the simple and natural explanations which they hide, engineering education will not make the rapid progress necessary for it.

A very little observation will suffice to show "A.R.L." that there is a close analogy between knowledge of what he terms "this powerful method" and the mispronunciation of simple English words. Both are engendered by the same kind of teaching; and both are evidence of the (for engineering) unsuitable state of mind produced thereby.

I am sorry if "A.R.L." really considers that my article will only do harm by encouraging non-technical engineers to despise what they do not understand; for the sole object of it was to draw attention to the fact that engineers are resenting the obstacles placed in their way to prevent their study of such matters, and to show that all such obstacles may be easily removed. It is a sad fact that there are things which hamper and retard the progress of engineering education far more effectively than do those which "A.R.L." instances as provocative of mirth in "backward" British drawing offices; and it is a still sadder fact that any attempt at improvement in such directions is invariably resented, obstructed and ridiculed by those who could, if they would, do most to help.

Yours faithfully,
ERNEST G. BECK.

London, January 15, 1923.

AMERICAN AIRPLANE SUPERCHARGERS.

TO THE EDITOR OF ENGINEERING.

SIR,—In Professor Rateau's valuable paper, "The Use of the Turbo-Compressor for Attaining the Greatest Speed in Aviation," presented at the Paris meeting of the Institution of Mechanical Engineers, and printed in your issue of July 28, 1922, the American supercharger work is presented in rather an unfavourable light.

American engineers have the greatest respect for Professor Rateau's ability, and there is no reason for any misunderstanding. It is quite true that as Professor Rateau states, the work of the General Electric engineers was begun after knowledge of the work in France. This has always been freely stated, and no attempt whatever, has been made to conceal it. The fundamental idea of the use of a gas turbine wheel in series with internal-combustion engine, is, of course, quite old. The idea of using a compressor of some kind to supercharge an internal-combustion engine at high altitude, is also quite old. The General Electric engineers have never made any claims to invention of these features.

The General Electric Company has for many years been engaged in research and commercial work, on gas turbines, steam turbines, and high-speed centrifugal air compressors. We have produced great numbers of commercial machines of the two latter classes. Having the benefit of the experience thus accumulated, having knowledge of work which had been done in compounding an internal-combustion engine with a gas turbine, and in precompressing air for internal-combustion engines at high altitudes in mountainous regions, or on airplanes, and having, as Professor Rateau states, knowledge of what had been done in France, we set out to design a turbo-supercharger. We used throughout, the actual details which had been perfected in our years of previous work on gas turbines, steam turbines and centrifugal compressors, and this resulted in a final design in nowise resembling Professor Rateau's design. We have, as Professor Rateau states, been able to supercharge larger engines at higher altitudes, than has previously been possible.

Yours faithfully,
SANFORD A. MOSS,
Mechanical Department, Thomson Research Department.
General Electric Company's River Works, West Lynn, Mass., U.S.A.

"THE DIFFICULTIES OF PAYMENT BY RESULTS."

TO THE EDITOR OF ENGINEERING.

SIR,—May I ask your permission to make a few comments on the leading article in your issue of the 12th inst. on the "Difficulties of Payment by Results," in which reference was made to a paper read by the writer before the Institute of Industrial Administration. Many of the views expressed in that article are in accord with those of the writer, but there are a few points of divergence which appear to call for a further reference.

The absence of an expression of opinion by the author of the paper, as to which of the various systems of payment by results in use is likely to survive, is commented upon, and it is also stated that "the fundamental question as to what is the best method of payment by results is left unanswered." These comments are fair; no such lead was given, nor was it the author's intention so to do, and, therein, his views would appear to differ from those expressed in your article. The view held is that the troubles of the past have not lain with systems, and that even as this is so neither does the solution of those troubles depend upon the use of any particular system. The reason for the trouble is thought to go deeper, and although the importance of systems is appreciated, they are not regarded as being fundamental.

Agreement with the author of the paper is expressed in that "if any system of payment by results is to be successful the rates must be based upon accurate data as to efficient conditions of working"; it is said, however, that "no one indeed would dispute these statements but they do not carry us much further."

But, Sir, is not this the pivot upon which the whole situation turns. If the acceptance of the need for job rates to be based on accurate data, which reflects efficient conditions of working, is such as not to be disputed and, further, is recognised in practice, it might be expected that stability of job rates would be possible. Doubt, however, is expressed as to this possibility, and reference is made to the experiences of the war-period when, on repetition machine work, operators acquired "an almost incredible expertness," which "no one however conversant with the possibilities of machine tools could foresee." It is undoubtedly true these possibilities were not foreseen, but is it equally true to say they could not have been foreseen? The question is a most important one because conditions of a somewhat similar nature will always be with us and must be considered in regard to future policy.

Is it not a fact that during the war-period, what was regarded as a phenomenally large output in one factory was treated as being more or less normal in another factory, and that the expertness acquired was not more than should have been expected? The writer remembers arranging to send an official from a works in one district to a works in another district far away, for the sole purpose of enabling him to see the difference in the rate of movement of the operators, in the hope that he would be convinced that that rate of output which had been estimated as possible was, actually, possible.

Again, an illustration may be cited which represents a typical and not an isolated experience. During the war in works "A" a lathe operation was in question. The work involved was estimated to be a four hours' job, and a job rate based on this amount was offered accordingly. The workman ridiculed the rate, stating the job could not be done in less than eight hours; but he said further that in another works a few miles off a piecework rate of 20*s.* was being paid for the same operation done under similar conditions, or five times the amount offered in works "A." The statement was verified, but the job was done eventually in four hours. It is suggested that if the rate of output achieved in works "A" had been reached in works "B" this would have been regarded by them, probably, as a wonderful increase of output which could not have been foreseen.

It is submitted that what is needed principally in connection with payment by results is a changed outlook as to the possibilities of a reasonably accurate measure of output. Scepticism or indifference in this respect is too common, and is not confined to workmen. The belief appears to be that job rates cannot, generally speaking, be right in the first place, and that some provision must always be made for counterbalancing these supposedly unavoidable errors. To this end job rates under the piecework system have been cut, and premium systems have been introduced with more or less drastic reducing factors for the purpose of obviating the need for cutting the job rates. None of these have proved successful as is indicated by the present general attitude.

Cannot the possibilities of output be ascertained before, rather than after, the application of payment by results, and by so doing, enable such correctives, as may be necessary, to be applied before job rates are fixed. If so, a great step in the direction of obtaining efficiency will have been taken and the need for corrective factors with systems of payment by results and for the cutting of job rates, whether that need be apparent only or real, will be rendered almost, if not entirely, unnecessary. Does not the success of the future lie with policy rather than systems? Such is the writer's belief, and is the reason the recommendations looked for were not made.

I am, yours truly,
J. E. POWELL.

Camcot, Crook Log, Bexleyheath, Kent.
January 16, 1923.

ALMANACKS AND CALENDARS.—We have received a daily tear-off calendar from Messrs. Ashwell and Nesbit, Limited, engineers and ironfounders, Leicester, Manchester, &c., depicting the de Montfort Hall, Leicester, the heating and ventilating of which has been carried out by them.—Messrs. Haslam and Stretton (Engineering and Motor Utilities), Limited, state that such is their correct title and not as given on page 24 *ante*.—A monthly tear-off calendar has also reached us from the Petro-Flex Tubing Company, Limited, manufacturers of Petro-Flex patent flexible hose, Cassiobury Works, St. Albans-road, Watford (Herts).

THE SURVEYORS' INSTITUTION.—The annual country meeting will be held in Edinburgh on June 27, 28, 29 and 30. A committee of the Scottish Branch, of which Mr. J. I. Davidson, senior vice-president of the Institution, is chairman, is engaged in drawing up the programme and making the necessary arrangements. Particulars of these will be published later, but meanwhile members are requested to make a note of the dates. Mr. J. E. Drower has been nominated to represent the Institution on a sub-committee of the British Engineering Standards Association which has been appointed to advise as to the standardisation of cast-iron, half-round, O.G., and other moulded gutters.

COMMERCIAL AVIATION IN THE COLONIES.—We understand that it is proposed to establish an air service for passengers and mails between Cape Town and Johnannesburg, calling at Blomfontein *en route*, and that subsidiary services to Pretoria and Durban are also contemplated. These routes will all be supported by the South African Government. In New Zealand a regular service for goods and passengers is proposed between Gisburn and Auckland, and in Australia four air mail routes are receiving Government support. The four Australian routes are as follows: Geraldton to Derby in Western Australia, Sydney to Brisbane, Sydney to Adelaide, and Charleville to Cloncurry in Queensland. In all cases above referred to British-built aeroplanes, fitted with Rolls-Royce engines, have been selected for use.

NATIONAL UNION OF SCIENTIFIC WORKERS.—The annual council meeting of this association was held at the Caxton Hall, Westminster, on the 13th inst. Dr. A. A. Griffith, who presided, gave an address on "The Support and Utilisation of Science," in which he stated that it was the general opinion of men of science that the support of science in this country is quite inadequate considering the needs of the country. Although science was the greatest and most permanently valuable of all the learned professions, it was the worst paid. Scientific workers, he added, would only prove their value to the community when they undertook a greater share of responsibility in the control of the product of their labours. Unity among men of science was the first essential of success.

THEORETICAL ADVANTAGES OF ELECTRIC MELTING OF BRASS.—The theoretical advantages of electric brass melting are summarised by the United States Bureau of Mines as follows: (1) Melting may take place in a neutral or reducing atmosphere, thus minimising loss of metal by oxidation and improving the quality of the product through freedom from oxides; (2) metal of crucible quality may be obtained without the use of crucibles; (3) melting may take place in a tightly-closed chamber, or at least in one free from the constant passage of the products of combustion of fuel, and thus losses of volatile metals, such as zinc and lead, may be reduced. Contamination by sulphur from fuel is avoided: (4) in some types of electric furnaces the temperature may be more readily controlled than in fuel-fired furnaces; (5) in some types of furnaces the molten metal is thoroughly stirred, thus giving a uniform product, even with large heats; (6) There is no handling or storage of fuel, such as coke, coal, or oil, and no ashes have to be removed. The cost of power can be more accurately predicted over longer periods than the cost of fuel; (7) working conditions about the furnaces are less dangerous to health and safety of workmen, provided suitable types of furnaces are chosen; (8) The above advantages may be obtained in furnaces of larger capacity than can be used satisfactorily in the fuel-fired crucible types, with resulting greater uniformity of product, accompanying lower labour costs, and considerably increased production.

THE CAMBRIDGE MICRO-STRESS RECORDER.

CONSTRUCTED BY THE CAMBRIDGE AND PAUL INSTRUMENT COMPANY, LIMITED, LONDON.

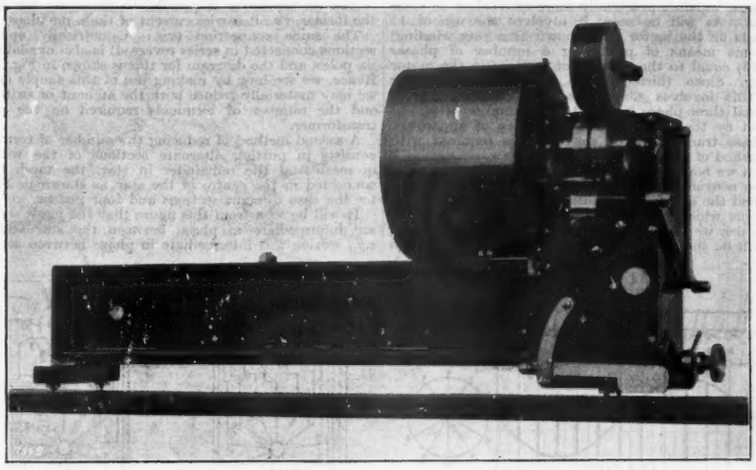
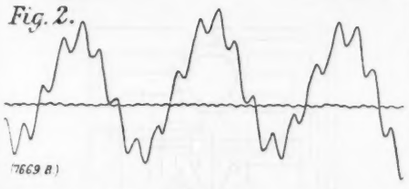


FIG. 1.

Fig. 2.



(7669 B)

THE micro-stress-recorder of Mr. W. G. Collins, which we illustrate in Figs. 1 and 2, above, was one of the novelties which the Cambridge and Paul Instrument Co., Ltd., of 45, Grosvenor Place, S.W 1, showed at the Physical and Optical Societies' Exhibition and which we briefly mentioned in our comments on the exhibition published in our issue of January 5. The recording devices of the new instrument work on the principle which Mr. Collins has successfully adopted in his micro-indicator; this latter instrument was described on page 716 of our issue of June 9 last. The micro-stress-recorder will measure and record varying stresses such as the stresses arising in bridges when trains are crossing at various speeds.

In Fig. 1 the instrument is seen resting on a steel bar, to which it would be fixed by a clamp engaging on the conical stud shown on the top of the main beam of the instrument. Contact with the bar of the girder is made by means of the two fixed points shown on the left-hand side of the photograph. To these fixed supports correspond two points on a moving member at the other end. This member is temporarily clamped by a small lever seen at the right-hand bottom corner. The milled head also shown there serves for the horizontal adjustment of the device. When the girder or surface under test is vibrating, a style attached to the moving member impresses a record on a moving strip of celluloid. This strip is fed off the small drum at the top of the photograph, a little behind the double roller which pushes the tape forwards. The driving power is supplied by the clockwork inside the big cylinder which can be seen in the photograph. Underneath the double rollers there is a friction roller which is thrown in and out of gear by the aid of the large lever, mounted on the side of the instrument box. The back of the box can be taken off. A vertical spring inside the box keeps the parts in active contact.

The micro records obtained are examined under a simple microscope, as in the case of the micro-indicator. There is ample sensitivity, since the records can be read to 0·01 mm.; with steel this distance would correspond to a load of 0·022 kg. per square millimetre, or to 0·035 ton per square inch. The zero line and time records are drawn on the inside of the film, the latter at intervals of half a second. The film speed can be adapted to the requirements. The instrument as made works over a base line of 250 mm.; but this distance can be reduced if desired. The record is fifteen times the size of the actual movement of the girder. With the microscope the total magnification is 400. Fig. 2 is a record obtained by striking the steel bar, and the record of the vibrations of a tuning fork. The lines of the curves which are given mark the centre lines of the impression produced on the celluloid.

The new instrument offers several advantages. The instrument records directly and does not depend upon photography, though the records obtained, which need no further preparation for preservation, may be, of course, enlarged photographically without difficulty. The mechanism is entirely clock-driven, and does not require any battery or electric lamps for operation. Free vibrations at a frequency of 1,000 periods per second have easily been registered, but that is by no means the limit of the capacity.

VARIABLE-SPEED ALTERNATING-CURRENT MOTORS WITHOUT COMMUTATORS.*

By F. CREEDY, Associate Member.

INTRODUCTION.

IT has become sufficiently clear during the past few years that the polyphase alternating-current system will ultimately be universally adopted for power supply on a large scale. One of the chief difficulties at present existing with this system relates to the provision of a satisfactory variable-speed motor, capable, if possible, of operating on high-tension polyphase currents without the necessity for the transformation of the whole of the power. The solution of this problem is very far from being an easy one and, in fact, it is only in comparatively recent years that satisfactory progress has been made.

In the first place, the different applications for a variable-speed motor vary very widely among themselves, and it is by no means likely that a single type of motor is best adapted to meet the whole of the these different forms of application.

It will be desirable first of all, therefore, to consider rather more in detail what is the real nature of the problem of producing a satisfactory variable-speed alternating-current motor to meet every kind of practical condition.

THE PROBLEM OF VARIABLE-SPEED ALTERNATING-CURRENT MOTORS.

There are, in fact, a considerable number of different classes of variable-speed service.

These may be more or less accurately summarised as follows :—

(1) *Speed-Range.*—All practical applications, with very few exceptions, can be covered by a motor having a speed range of 3—1. Other speed-ranges in wide demand are 2—1 and 1·5—1. It would, of course, be desirable, if compatible with the other conditions of the problem, to have a machine capable of gradual speed variation from one end to the other of any of these ranges without continuous loss of power at any speed. If this should not prove possible, and it becomes necessary to use a number of speed steps, these should be fairly numerous, say not less than 4 to 6, in a speed-range of 3—1.

(2) *Starting.*—In certain cases, *e.g.*, the compressor drive, the printing press or the reciprocating pump, variable-speed motors must be capable of starting with a very high torque, while others, *e.g.*, machine tools and fans, require only a moderate starting torque, hence provision must be made for both these cases.

(3) *Speed Changing.*—In certain cases, *e.g.*, machine tools, printing press drives, compressors, lifts and cranes, &c., the speed has to be changed under load, while again in others, *e.g.*, mine fans, pumps, calenders and merchant mills, the speed is only changed occasionally in changing operations, though here, of course, the speed variation required in order to render the use of a flywheel possible is not referred to, but merely that required to enable the mill to deal with different classes of work.

In these cases there is no serious objection to shutting the machine down and re-starting, and where this is possible the problem is simplified to a considerable extent.

Where the change of speeds is in steps, care must be taken that the change from one step to the next is effected without a serious shock to the system, either mechanical or electrical.

(4) The first cost of the equipment, as well as the cost of attendance and upkeep, must be moderate. Repairs must be capable of being carried out without difficulty.

(5) The efficiency of the equipment should be as high as possible, since high efficiency over a large range of speeds is the chief object of installing a variable-speed alternating-current motor. A low consumption of wattless current is also desirable.

(6) For the vast majority of applications the motor should be capable of giving a constant torque at all speeds or a horse-power proportional to the speed. For a certain class of machine tools, however, a constant horse-power characteristic is desirable.

The object of speed variation in the driving of machine tools is to enable a cut to be taken on different diameters at the same peripheral speed, objects of large diameters being driven at a low speed (revolutions per minute), and objects of a small diameter at a higher speed. Where, as in lathes, modern drilling machines, milling machines, &c., the amount of energy dissipated in friction is small and most of the power of the drive is actually devoted to cutting, this means that approximately the same horse-power is taken by the tool at no matter what speed it operates.

There is, however, another class of tool in which the size and weight of the tool is determined chiefly by the necessity of rigidity, *e.g.*, large boring mills, planers, &c. In this case the greater part of the energy supplied to the tool is devoted to the moving of heavy masses and is ultimately dissipated in friction. In this case the tool requires a constant torque and an amount of power in proportion to the speed.

DIFFICULTIES IN DESIGNING A SATISFACTORY VARIABLE-SPEED ALTERNATING-CURRENT MOTOR.

The most obvious way to produce such a motor is to make the closest possible imitation of the direct-current machine, and it has long ago been shown that numerous types of single-phase and polyphase commutator machines having, in theory, characteristics resembling very closely those of the direct-current machine are possible. These commutator machines have never been more clearly described than in a lecture* given by Dr. S. P. Smith, but it is indisputable that the present wide utilisation of electric-power supply is due very largely to the simplicity and robustness of the polyphase induction motor, and I have always thought it a disastrous mistake to abandon the induction motor without examining whether some system of control cannot be worked out so as to enable it to carry out satisfactorily without any fundamental alteration variable-speed requirements.

Every variable-speed application should, in my opinion, be considered on its merits. In the cases given below a commutator machine is undoubtedly the right apparatus to use.

(1) On constant-speed work where it is possible to keep the size of the commutator and the amount of brush gear within reasonable limits by appropriate design.

(2) On very low-frequency circuits where similar possibilities exist.

(3) Where there is an imperative demand for a continuously adjustable speed justifying all the sacrifices in other directions which must be endured in order to attain it. These cases are, however, in my opinion, relatively few. Assume, for instance, that we wish to drive a boring mill by means of a variable-speed alternating-current motor, the best speed of the table for a particular class of work being 20 r.p.m. With a speed control by steps it may be impossible to get exactly this speed, speeds of 19 r.p.m. or 21 r.p.m. being the nearest available, and I feel that this difference is not worth considering in most cases.

Confining ourselves therefore to methods of controlling the induction motor so as to obtain variable-speed shunt characteristics, we find that its natural lines of development are two in number :—

(1) Speed change by changing the number of poles.

(2) Speed change by cascade operation.

Both these methods lead to extremely useful types of apparatus and I propose to discuss each in turn.

PART I.

SPEED CHANGE BY CHANGING THE NUMBER OF POLES.

Without ignoring the work of early inventors, such as Dahlander and Lindström and Alexanderson, who have provided means of adapting a single winding to give, for instance, two numbers of poles having a fixed ratio, it is not unfair to say that the idea of using the method of pole changing to produce a machine having anything resembling a gradual variation of speed by small steps between wide limits, would have been regarded a few years ago as chimerical. Yet it is also obvious that if by any means we could render practically available all the numbers of poles which exist within a given range, we have a machine with a very high degree of practical usefulness. For instance, on 50

* Paper read before the Institution of Electrical Engineers on January 4, 1923.

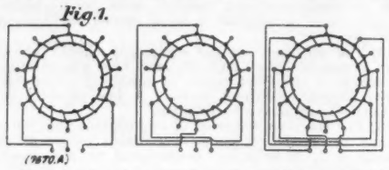
* Journal I.E.E., 1922, vol. lx, page 308.

periods between the speeds of 375 r.p.m. and 1,000 r.p.m. there are six numbers of poles available.

As the methods by which all these numbers of poles are rendered practically available have not yet been publicly described, I propose to dwell on them at somewhat greater length than is devoted to the methods of speed variation previously described.

One method by which all these numbers of poles might theoretically be rendered available with a single winding has long been known, *i.e.*, the use of a ring winding tapped at the various points necessary to give different numbers of poles, as shown in Fig. 1. It is well known that a ring winding can be used on any

Fig. 1.



number of poles, if a number of equidistant tappings equal to three times the number of pairs of poles are brought out on each speed, equaliser connections being made between tappings 1 to 4 throughout the circumference. To obtain six numbers of poles from the same winding in this way, however, would require a formidable number of tappings, and to connect them together in the various manners required would involve an equally formidable type of switch gear.

In addition to this, the ring-wound machine is highly inconvenient from a manufacturing standpoint, though practically equivalent results could, in fact, be obtained from a lap-wound drum winding.

A further difficulty arises from the fact that the voltage induced in any section of the machine consisting of, say, two, three or more coils connected in series having a given number of turns is proportional to the rate at which the magnetic lines cut the conductors, and this rate is, of course, proportional to the speed of the flux wave, which is practically the same as that of the revolving element. Consequently, at the highest speed of the motor, the flux wave is cutting the conductors at a very high rate and, if the E.M.F. applied to any section is fixed, only a small flux will be required to produce it, owing to the high rate of cutting.

On the low speed of the motor, on the contrary, the flux wave is cutting the conductors at a low rate and, consequently, if the E.M.F. across the sections remains the same as before, a large flux will be necessary to produce it.

Hence the flux of the motor will tend automatically to fall off in proportion to the rise of the speed in much the same way as it does in the direct-current motor, and hence such a motor having a constant voltage per section, will tend to have a constant horse-power characteristic, which is not at all what is demanded in practice.

Means must therefore be provided to increase the voltage across each section more or less in proportion to the speed. These difficulties may be summarised as follows:—

(1) The difficulty of producing a winding having a moderate number of terminals and capable of simple switching.

(2) The difficulty of varying the voltage across a section containing a fixed number of turns, so as to keep the flux approximately constant with increasing speed without the use of costly apparatus.

Method of Overcoming these Difficulties.—The solution to all these difficulties was only found gradually. In order to overcome the necessity for a very large number of terminals, a method of pole changing entirely different from that described above was adopted. This method is shown in Figs. 2 and 3. Still considering a ring-wound machine, assume it to be divided into 12 sections, shown developed in Fig. 2.

At this point it may be convenient to describe a diagrammatic method of denoting the windings of alternating-current machines which I have developed in order to simplify winding diagrams. It will be seen that the ring winding shown at the top of Fig. 2 is divided into 12 sections, each section being shown as consisting of two turns. The beginning of each section is denoted by a white circle and the end of a smaller blackened circle, the extremities of the various sections being connected in series in the usual manner. An obvious simplification for diagrammatic purposes is to omit the drawing of the winding and merely retain the two terminals of each section, joining them by a straight line in order to show that they belong to the same section. This diagrammatic method of denoting the winding is shown immediately below the drawing of the ring in Fig. 2, the sections being numbered in order round the circumference, and the method is made considerable use of in these notes.

Imagine the 12 sections of the ring winding shown in Fig. 2 to be carrying currents differing in phase from one another by 60 deg., the current vectors being shown on the right of Fig. 2 (*b*), the current in section 1 having a phase 0 deg., that in section 2 having a phase 60 deg., that in section 3, 120 deg., and so on. These vectors when projected on a vertical axis in the usual way give, of course, the instantaneous currents in the different sections, which may be plotted as shown on the left of Fig. 2 (*b*). We thus obtain a series of ordinates the extremities of which lie on a sine curve, having two positive and two negative maxima, *i.e.*, four poles on the circumference. If, however, we so reconnect these sections that the phase difference between adjacent sections is 30 deg. and plot out the ordinates as in Fig. 2(*a*) we obtain another sine curve having one positive and one negative maxima, *i.e.*, two poles, while if we make the phase difference between the sections 90 deg., as in Fig. 2 (*c*), we obtain a curve having three positive and three negative maxima, *i.e.*, six poles.

In Fig. 3 are shown the connections whereby this change of phases may be accomplished for the case of 13 phases, which is practically more convenient in some respects. As will be seen, it involves the use of 13 terminals on the motor (still shown as a ring winding) and some means of producing a number of phases (viz., 13) equal to the number of sections in the motor winding. Since thirteen-phase distribution is never used, this involves some means of converting from the usual three-phase supply to the number of phases required by the motor and a new piece of apparatus, the phase transformer or converter, is required with this method of control.

When we realise that this method of control involves a phase converter, it may appear as if we had merely simplified the switching by introducing another piece of apparatus which will cost as much as the switch gear with which we have dispensed.

It will be shown later, however, that this is far from

Fig. 2.

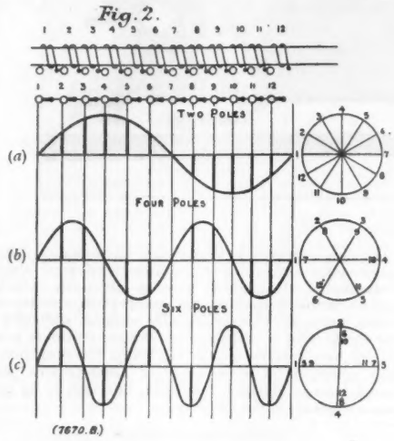


Fig. 3.

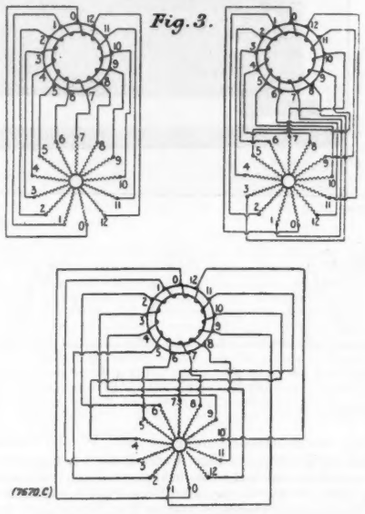


Fig. 4.

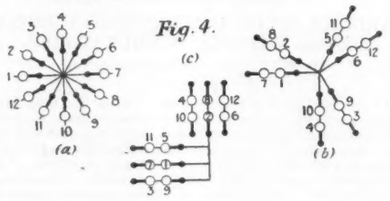


Fig. 5.

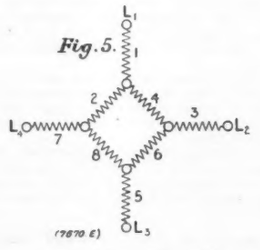
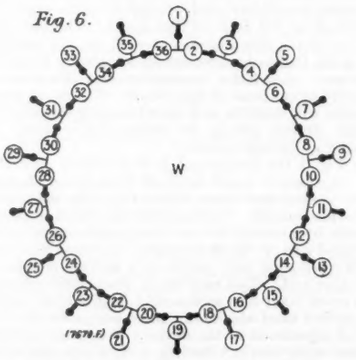


Fig. 6.



being the case. The construction of this phase transformer with a suitable degree of simplicity involves problems of its own, particularly where a large number of phases are required. The method of solving these problems will be described at a later stage.

Although the simple method of pole changing just described was sufficiently encouraging to justify the construction of one or two machines for special purposes, it was not found sufficiently simple to be the final solution of the problem. Experience showed that even the number of terminals possessed by such a motor was too great in practice if a large number of speeds, *e.g.*, five or six, was aimed at. In this case the number of terminals is not less than 30, which was found to be not a practical number, and still further means of simplification were therefore sought.

It was found possible to reduce the required number of terminals in several ways. It is clear, first, that wherever we have currents differing 180 deg. in phase, that is to say, mutually reversed, it is not necessary to supply two distinct phase-transformer terminals to obtain these two phases. If the two sections are connected in series or parallel, mutually reversed, they can be supplied from a single terminal.

For instance, returning to Fig. 2, if we wish to connect the motor only for two poles and six poles we find that in both these cases sections 1 and 7, 2 and 8, &c., are diametrically opposite in phase. We may therefore connect them in series reversed, as shown in Fig. 4 (*b*), in which the sections are denoted by the diagrammatic method already described, and the direction of the straight line joining the two extremities is made to represent the phase of the current in the section.

Connecting all the sections in star, we require 12 terminals to give two poles. Connecting opposite sections in series reversed we require only six, although if we compare Figs. 4 (*a*) and 4 (*b*), we see that each section in the latter is parallel to the same section in the former, *i.e.*, it carries current of the same phase.

The same connection (viz., diametrically opposite sections connected in series reversed) is also available on six poles, and the diagram for this is shown in Fig. 4 (*c*). Hence, we see how by making use of this simple device we may materially reduce both the amount of switching and the number of terminals required on the phase transformer.

A second method of reducing the number of terminals consists in putting alternate sections of the winding in mesh and the remainder in star, the mesh being connected in the centre of the star, as shown in Fig. 5, for the case of eight sections and four phases.

It will be seen from this figure that the mesh sections are intermediate in phase between the star sections, *e.g.*, section 2 is intermediate in phase between sections 1 and 3, and so on, thus, although the winding connected as in Fig. 5 requires only four terminals, the E.M.F.'s across the various sections are nevertheless in eight distinct phases.

Again, it was found in most cases that while this method of connection might suffice to double the number of phases on a particular number of poles, yet in order to produce the same result on another number, the whole or many of the sections must be disconnected from one another and reconnected in a different order. Thus it would seem that we have only simplified the transformation in order to complicate the switching.

The method of reversal and the star-mesh method may be combined, and thus we may obtain windings in which the E.M.F. across the sections has four times as many phases as that supplied to the terminals.

After a very large amount of research, extending over a considerable period of time, a winding was found in which this result could be accomplished, not on one number of poles only, but over a large series of numbers covering a speed range of 3—1 or more, without reconnecting the winding in any way when changing the numbers of poles. This winding is shown in Fig. 6 for the case of 36 sections, 18 of which are connected in mesh and an equal number connected in star to the angles of the mesh, alternate sections in the mesh being mutually reversed and alternate sections in the star being also mutually reversed, the mesh sections alternating with the star sections around the circumference of the machine.

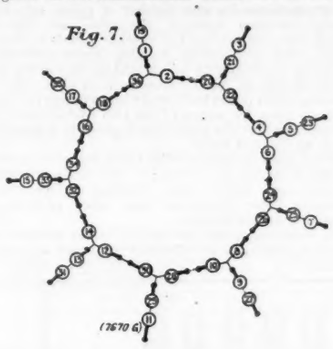
The winding shown in Fig. 6 (containing only 18 terminals) can be, and is being, frequently used on all numbers of poles from 6 to 16 and is, with a slight further modification, also capable of being used on further numbers of poles from 20 to 26.

This connection, therefore, gives us not only a winding of a very simple character with a moderate number of terminals (18) capable of reconnection in a simple manner for a large number of different numbers of poles, but it also gives us the characteristic which was shown above to be desirable, viz., that of having an approximately constant flux on all numbers of poles. It is difficult to explain the cause of this in a simple manner, but one may say briefly that it is due to the fact that the number of sections in series between terminals having a given phase difference of, say, 120 deg., becomes gradually greater and greater as we increase the number of poles, or decrease the speed, so that as the rate of rotation of the flux wave gets less and less, due to the decreasing speed of the motor, the voltage across any section having a given number of turns also becomes less and less approximately in the same proportion, and thus about the same flux is needed to balance this voltage at all speeds.

A further simplification is possible where, for instance, only odd numbers of pairs of poles are required and, consequently, diametrically opposite sections are always opposite in phase on every number of poles which a machine is required to give, and, therefore, may be permanently connected in series, mutually reversed.

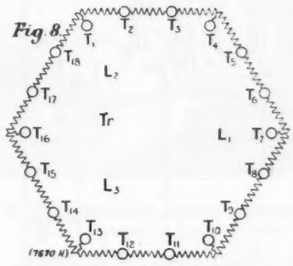
The winding of such a machine is shown in Fig. 7 and, as will be seen, has only 9 terminals, capable of operating on 2, 6, 10 and 14 poles, and, with a slight further modification, on 22 and 26 poles. This winding is, I believe, the simplest known multi-speed winding. It requires no more than 9 phases, while the original winding may require 18 phases.

Fig. 7.



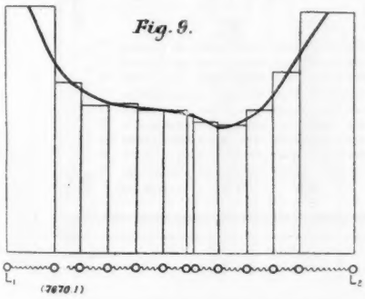
(7670 G)

Fig. 8.



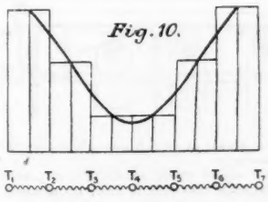
(7670 H)

Fig. 9.



(7670 I)

Fig. 10.



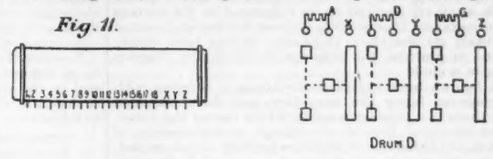
(7670 K)

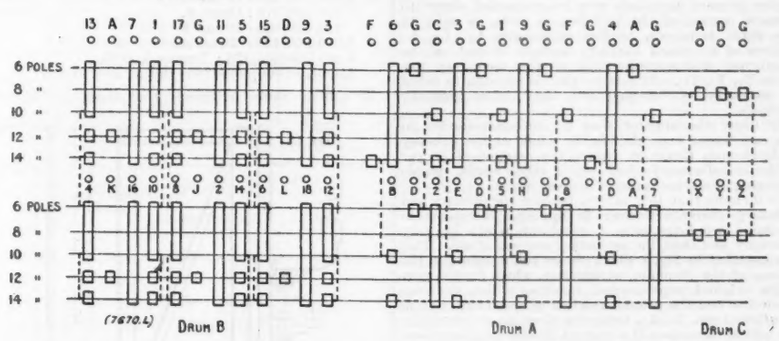
The Phase Converter.

Having described how the difficulties connected with designing a multi-speed winding have been overcome by means involving the use of a phase transformer or converter, it will next be desirable to describe how this apparatus is constructed in practice. In certain cases, *e.g.*, where a single motor is operated from a generator which serves no other purpose, as in ship propulsion, no such transformer is needed, as there is no difficulty in winding the generator for the number of phases required, but in the majority of cases the machine, if it is to be of any practical use whatever, must operate from a power supply having, say, not more than three phases, and hence it is of vital importance to the practical success of the apparatus that this phase transformer should be not merely technically satisfactory, but should also be capable of being built at a very moderate price.

By restricting the number of phases to multiples of three, the transformers to be excited from a three-phase circuit may be simplified very materially, and it will be convenient to describe the transformer as used in connection with the winding previously referred to. This transformer does not differ externally in any way from the standard three-phase core-type transformer, built in the usual way with three exactly similar limbs. The connections, however, are as shown in Fig. 8, in which all the windings shown by lines parallel to one another are considered to be wound on the same limb of the transformer. Since the windings shown in this figure are drawn parallel to three straight lines

Fig. 11.





(7670.4)

Fig. 12.

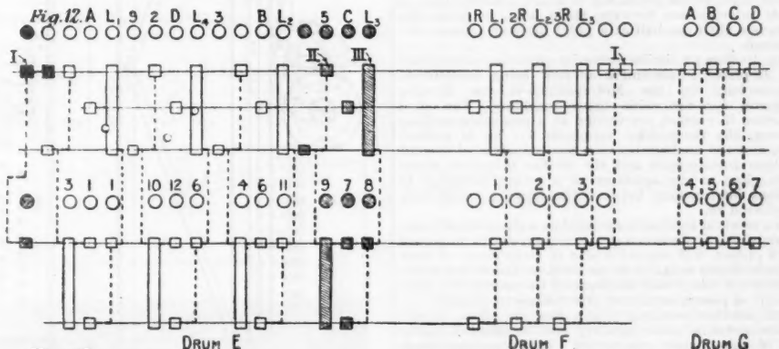
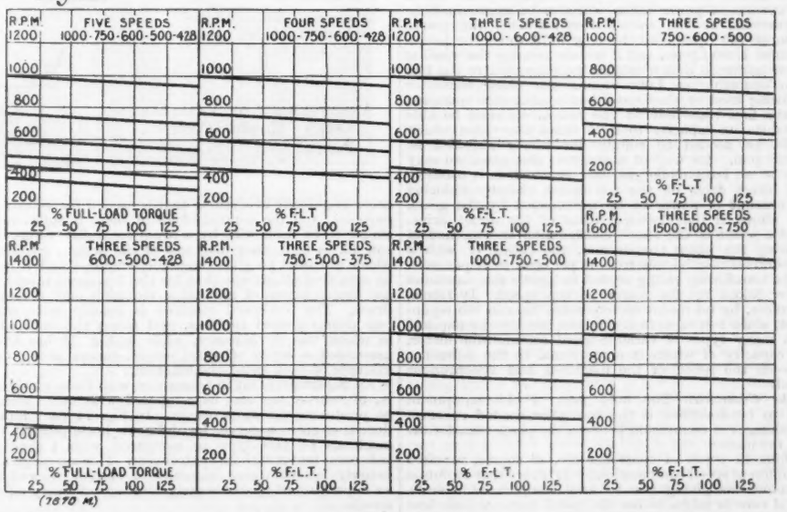


Fig. 13.



(7670 M)

at 120 deg., it follows that only three such limbs are needed.

If we take a three-phase transformer having two secondary sections on each limb, and connect these sections in the manner shown, which may be called a hexagon connection, we obtain an apparatus from which six-phase currents may be derived by bringing out terminals from the corners of the hexagon. If however, we tap the sides of the hexagon in the manner shown, winding on the three limbs, in addition, six small, auxiliary sections to be connected to the corners of the hexagon, it is possible without further elaboration to obtain no less than 18 phases, as has been amply proved in practice, the tappings shown in the diagram lying in a circle.

So far, we have regarded the hexagon winding with tappings as being the secondary, and have assumed that there is a primary winding which carries the three-phase-currents. But if no voltage transformation is needed, as in this case, a separate primary is not needed, for the primary terminals may be connected direct to alternate corners of the hexagon, or even, in order to save extra terminals, to the extremities L_1, L_2, L_3 of three of the small auxiliary sections wound on the transformer and corresponding to the secondary terminals T_1, T_7, T_{13}. This latter plan is adopted to avoid the necessity of bringing out three extra primary terminals.

By using the apparatus as an auto-transformer in this way we at once abolish the whole of the primary windings and, therefore, reduce the amount of copper on the transformer to half, or, in other words, double the rating of a transformer of a given size.

We do more than this, in fact, because the primary and secondary currents flowing in opposite directions in the same windings give a resultant which is very materially less than the secondary current alone. This is exemplified in Fig. 9 which shows the currents in the sections of the 30-phase transformer, which formed part of the original experimental machine which was constructed to test the present method of speed variation in its earliest form, L_1, L_2, being the three-phase terminals.

It will be seen that the current in the neighbourhood of the three-phase terminals is much greater than at points intermediate between them, and, in fact, falls off to less than one-half at a point midway between the terminals.

Fig. 10 shows a similar curve for up-to-date nine-phase and 18-phase transformers as now being constructed commercially by the Metropolitan-Vickers Electric Company for use with these machines. The same reduction in current per section at a point intermediate between the three-phase terminals T_1, T_7, is noticed here, and the analogy between the reduction of current in these transformers and the similar reduction which takes place in the armature of a rotary converter in sections intermediate between the tapping points may be referred to.

As a result of this further reduction, a phase transformer to transform a given amount of power, say from 3 to 9 or 18 phases, will require a size of transformer of only between 30 per cent. to 40 per cent. of the rating of the transformer which will be required to convert the same amount of power, say, from one voltage to another.

Still another economy which has the effect of still further reducing their capacity can be effected in the use of these phase converters. In a constant-torque motor giving a horse-power proportional to the speed, the amount of power taken will also be approximately proportional to the speed. For instance, the power taken at 750 r.p.m., will be only 0·75 times the power taken at 1,000 r.p.m., and if we can arrange the winding of our motor so that it is directly connected to the line when operating at 1,000 r.p.m., the phase converter not being used on that speed but coming into operation for the first time only at 750 r.p.m., we shall be able to reduce its capacity to 0·75 times the value which would be needed to supply the power required at 1,000 r.p.m. By way of analogy to this plan, we may refer to an automobile gear-box in which it is usual to give direct drive on the top speed, thereby reducing the amount of power to be transmitted by the gears. The above is the electrical form of the direct drive.

As a result of the above construction and method of utilising the phase transformer, the rating of such a transformer may be only from 18 per cent. to 22 per cent. of the transformer rating needed to handle the maximum power taken by the motor at top speed. It forms, therefore, by no means an expensive item in the equipment, much less so, in fact, than the transformer required with many types of variable-speed commutator motor, the capacity of which is proportional to the difference between the speed of the machines and synchronous speed.

The Controller.—The only part of the equipment still to be described is the controller needed to effect the changes of connection between the phase transformer and the motor.

Different types of controller are, of course, required for different speed combinations. It is very easy to obtain combinations giving rise to very complicated circuits, but if care is taken to use the speed combinations best adapted to known types of winding and to choose the types of winding best adapted for the speeds required, the following rule for three-phase circuits may be enunciated :—

A three-phase multi-speed motor for any number of speeds up to six, will require three times as many terminals as there are speeds.

That is, a multi-speed motor with a single winding on each member may be built for any number of speeds up to six, requiring no more terminals than if each speed were produced by a different winding. This does not mean that any arbitrary selection of numbers of poles can be built with no more terminals than these, but that by suitably choosing the numbers of poles within the range of 3—1, these results may be obtained.

For instance, the winding described above (see Fig. 7) is usually arranged for 6, 10, and 14 poles, and requires 9 terminals, thereby obeying the rule, but a winding arranged for, say, 8, 10 and 14 poles, would not obey the rule, although windings for 6, 8 and 12, or 6, 10 and 12, could be designed to obey it.

There is thus an amply sufficient selection of combinations for practical purposes, although there are a few abnormal combinations which fall outside the rule. Further research is rapidly lessening the number of these combinations.

A series of combinations adjusted with great care so as, on the one hand, to lend themselves to simple control, and on the other to cover most industrial requirements, is shown in Fig. 13, covering speed ranges on 50 periods as follows :—

1,500/1,000/750 : Drum F.
1,000/750/500 : Drum F.
750/500/375 : Drum F.
750/600/500 : Drums F + G.
1,000/600/428 : Drum A.
1,000/750/600/428 : Drums A + C.
1,000/750/600/500/428 : Drums A + B + C.

It will no doubt be agreed that these combinations cover practically everything that is needed for industrial purposes, and the control of all of them is sufficiently simple to be dealt with by a drum controller. Figs. 11 and 12, in fact, show diagrams of the drum controllers which are used to give these combinations and it will be seen that all, except that for the five-speed machine, are simple pieces of apparatus requiring only a single drum. The five-speed machine is usually built with two drums geared together, and forms the only case in which this is necessary, while in Fig. 13 has been assembled a series of speed/torque curves giving one example of each speed combination.

An important point in connection with these machines is, of course, the cost as compared with other means of producing the same results. In Fig. 14 (not reproduced) is given a curve, for different horse-powers, for machines of this type as compared with a slip-ring induction motor with its control gear. This curve ignores entirely the enormous economy of current secured by an apparatus of approximately constant efficiency on all speeds.

These controllers are suitable for small to medium sized motors, up to 200 h.p. The larger sizes, say from 200 h.p. to 800 h.p., are rather beyond the scope of drum controller, and consequently an apparatus of a different type is employed. In Fig. 15, as shown, such a large controller built by the Electric Construction Company, Limited, the makers of these equipments, from which it will be seen that the controller consists of a slate panel bearing what are essentially four, nine-bladed two-way switches with vertical axes. The switches are of the finger type as in drum controllers and bear on studs mounted in the panel. They can be clearly seen in the lower half of the figure, while on the right and left of these switches are the terminals for the phase transformer and motor, respectively. The switches are opened and closed in the proper sequence by means of cams which appear immediately above the switches. For each speed, two of the switches make contact, thereby connecting the 18 terminals of the motor to the line or the phase transformer, in the different ways appropriate to different speeds.

It is found, by taking advantage of the following fact, that the switching may be simplified. One half of the connections for one number of poles, say, eight, with the machine running clockwise, are identical with half the connections for another number of poles, say ten, with the motor running counter-clockwise. It conduces to simplicity of switching, therefore, if we make no change in these connections in changing from eight poles, to ten poles, but merely interchange two of the three-phase lines, by means of the two contactors shown in the upper half of the panel which perform a quadruple function, as detailed below.

(1) They serve to reverse the three-phase connections when this is required, in order to economise switching.

(2) They are fitted with overload relays (shown immediately below them) so that they perform the function of a circuit breaker.

(3) In changing from one speed to the next in any multi-speed motor, it is necessary to open the circuit which in most forms of switch gear gives rise to a certain amount of arcing.

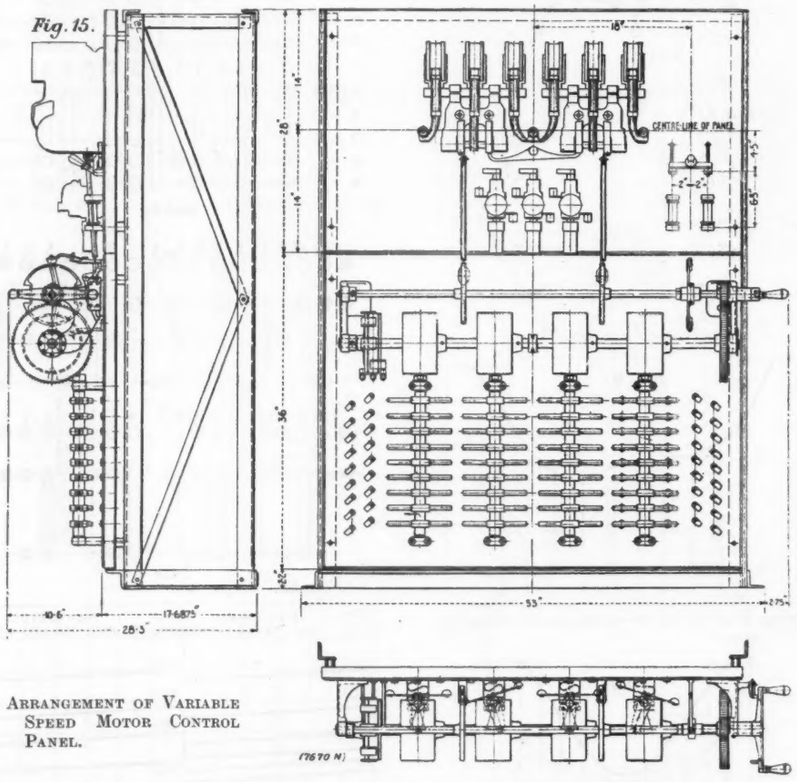
(I have for many years made it my practice in all such cases to open the circuit first, by a special switch designed with adequate blow-out apparatus, &c., to avoid arcing. Then, while the motor circuits are completely dead, to change the connections, which may, of course, be done without any arcing, because they are not carrying any current. And, lastly, to close the main circuit again through the switch specially provided for that purpose. The contactors shown in the figure perform this function also.)

(4) The small switch on the right serves to open the contactor magnets, and causes them to act as a line switch, isolating the whole of the apparatus from the line as soon as it is opened.

The connections on the back of the board are not unduly complicated and are carried out by means of bare copper rods about ⅜ in. diameter, in the standard manner. A mechanical interlock, formed by the vertical rods below the contactors, is fitted between the contactors and the camshaft by means of an auxiliary shaft geared to the camshaft, in the ratio of 1 to 4.

The operation of this interlock is as follows :—On making a slight movement of the controller handle, the contactor magnets are opened. No further movement is possible until both the contactors are fully opened. When this has taken place the shaft is freed, and on moving it further the cams begin to move and alter the adjustment of the main switches. When the handle of the controller has moved, say, 180 deg., then the adjustment has been completed and the magnet circuit of the contactors is re-energised, closing them when the machine continues to operate on the new

Fig. 15.



ARRANGEMENT OF VARIABLE SPEED MOTOR CONTROL PANEL.

number of poles. Although these operations take rather a long time to describe, they do not, in practice, take more than two seconds.

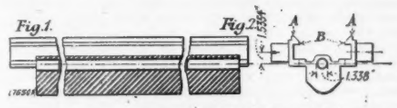
(To be continued.)

MACHINING AND LAPPING VERY DEEP HOLES.*

By Major JOHN B. ROSE,† Fort Leavenworth, Kan.

DURING the period of our war activities it is probable that no one manufacturing process called for the expenditure of more thought and skill by engineers and machinists than the production of the long and very accurately-formed cylindrical holes in the forgings from which gun-recoil mechanisms were made.

These cylinders or long holes varied in size from 1·575 in. to 7·875 in. in diameter and from 5 ft. to 8 ft. in length. To insure good performace it was required that the several cylinders have unusual accuracy of form,



LONGITUDINAL SECTION AND END ELEVATION OF FORGING

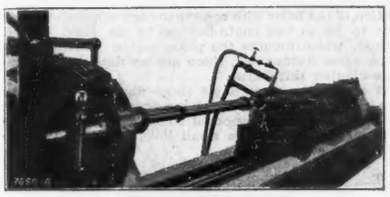


FIG. 3. FORGING MOUNTED IN LATHE FOR ROUGH-DRILLING OPERATION.

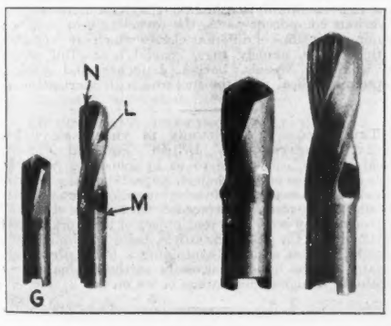


FIG. 4. HOLLOW-SHANK DRILLS USED IN DRILLING OPERATION.

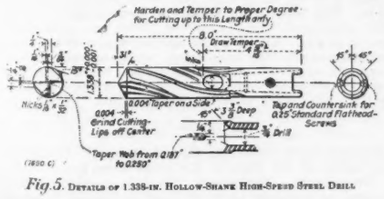

Harden and Temper to Proper Degree for Cutting up to This Length only
Draw Temper
.004 Taper on a Side
Grind Cutting Lips off Center
Taper Web from 0.187" to 0.250"
Drill

Fig. 5. DETAILS OF 1.338-IN. HOLLOW-SHANK HIGH-SPEED STEEL DRILL

size and position. While extreme accuracy of relative position was not demanded, it was largely obtained as a result of the care necessary to secure accuracy of the first two kinds.

It is believed the operations in producing these cylinders are without precedent in the United States, and certainly not on any scale of like magnitude. For this reason it is felt a record of certain of the machine set-ups and details of the processes should be of interest to shop engineers. It has very frequently occurred that devices or processes which were originally military in nature have found a more useful application in the arts of industry.

Mr. A. L. De Leeuw, Mem.Am.Soc.M.E., has contributed a series of articles to the *American Machinist*,‡ which very ably discuss the manufacturing operations carried on at the Singer Manufacturing Company, including the series of operations in the manufacture of the complete recuperator body. His articles should be read to obtain a comprehensive view where this is desired, and for a comparison of methods. It is here proposed to limit the discussion to the drilling, boring, reaming, lapping, and polishing of the holes. Even with this restriction it will not be practicable to cover within suitable limits more than one job which will illustrate production of the cylinders up to 2·6 in. in diameter. It is proposed to discuss these operations not in their connection with the building of a mechanism but in their relation to the pure art of such operations wherever they may be used. This paper then will avoid any technical discussion of recuperators or the history of their war production. It will record only the shop operations and to the extent that these may be of general industrial interest. The problem is to produce approximately parallel holes 5 ft. to 6 ft. long in a steel forging; the holes to be straight and round to a high degree of accuracy, free from visible scratches, and with a mirror-like finish.

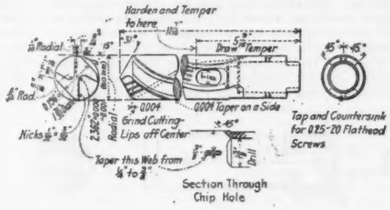

Harden and Temper to here
Draw Temper
.004 Taper on a Side
Grind Cutting Lips off Center
Nicks
Taper this Web from ⅛" to ¼"
Tap and Countersink for 0.25-20 Flathead Screws
Section Through Chip Hole

Fig. 6. DETAILS OF 2.362-IN. HOLLOW-SHANK HIGH-SPEED STEEL DRILL

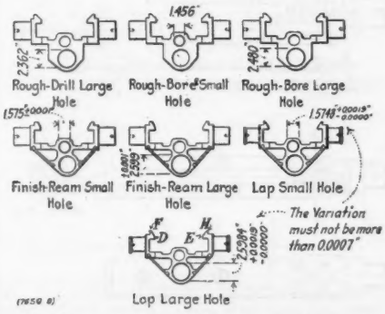


Fig. 7. BORING AND SUBSEQUENT OPERATIONS ON FORGING

FIG. 8. FIXTURE FOR ROUGH-REAMING OPERATION.

Drilling.—Figs. 1 and 2 show the shape of the forging ready for drilling the small hole (1·338 in. diameter and 63 in. long). The drill leaves the hole 0·236 in. under the final size. The average time for set-ups and through drilling was 3 hours.

The surfaces A and B (Figs. 1 and 2) were milled, and on these the forging rested in the fixture shown in Fig. 3. This fixture was made to insure correct centreing of the drill and is mounted rigidly on the carriage of a 25-in. heavy-duty Le Blond lathe. The bearing or guiding surfaces of the fixture were ground to correct location after trial on the lathe with which it was used.

Incorrect drilling was caused at first by the method of securing the piece. By means of two bolts attached to the tail end of the fixture and pulling on the piece, the latter was pressed so hard against the drill guide as to force it out of line and the drill ran at an angle. This was easily overcome by holding the piece against the drill guide by two bolts attached to the latter. The original error is obvious and should, of course, never have been made. On account of depth of the hole the drill was run in half-way, and the piece then reversed either on the same or on a second machine. Good results were obtained by both methods. It is very desirable that the drilled holes meet. If they do not, the accuracy of each following operation, even to the lapping, is affected, since each tool naturally tends to follow the hole it is enlarging. The correction of inaccurate drilling will be dealt with when considering later operations. In approximately 33 per cent. of all drilling the drills did not meet accurately, the maximum variation being $\frac{1}{8}$ in.

To secure speed it is necessary to provide efficient cooling and prompt removal of chips. Figs. 4, 5 and 6 show the hollow shank drills used for this purpose. A mixture of 1 quart of soluble oil with 3 gallons of water was boiled for half an hour and about a pint of sal soda added. This solution was forced under about 70 lb. pressure into the hole through the drill shank, along the oil clearance, over the end of drill and back through the flutes and hollow shank. Chips were reduced to narrow strips by cutting grooves $\frac{1}{16}$ in. by $\frac{1}{16}$ in., as shown at N, Fig. 4. The chips pass out with the oil through the hollow drill tube. In the earlier efforts the chips were not expelled satisfactorily, and it is probable that one of the principal causes of this was insufficient pump pressure. It was not practicable to increase the pump capacity and the remedy was effected by forcing air in with the oil. The small pipe in Fig. 3 carries the air at a pressure of 90 lb. This greatly improved expulsion of the chips and permitted continuous drilling. It is also necessary that the grooves in the drill be sharp-cornered and the passages leading to the interior or drill have polished round corners to avoid congestion of chips.

Figs. 4 to 6 show the characteristics of the drills used. In addition to features already noted, it was found very necessary to taper the drill 0·004 in. on a side. Some of the earlier drills used were not tapered and frequently broke due to seizing in the hole. The life of the drill depended largely on the forgings. The quality of these varied greatly as shown by Brinell tests. In some cases a drill might finish three holes before re-grinding, while again it would go only a few inches. With forgings of uniform proper machinability one drill should complete a hundred or more holes in its life.

It may be noted that the method of drilling used by the Singer Manufacturing Company was quite different from the Rock Island method described. At this company's shops the forging was mounted in a revolving steady rest and the drill run in a counter direction. No air was used. The drill itself was similar but 0·021 in. larger. It was run in half-way and then the entire fixture and forging reversed as a unit. In drilling the large hole next described, Singer held the drill stationary. It was desired to rotate the drill also, but delivery of suitable machines was delayed.

In drilling the large hole, all features of the operation were essentially identical with those in drilling the small hole, except that the hole being off the axis of the forging, the latter could not be reversed in the same fixture, but went to the next machine. The drill for this operation is shown in Figs. 4 and 6, the characteristics of operation being as follows :—

	Small Hole.	Large Hole.
Drill size, in.	1·338	2·362
Speed, r.p.m.	248·00	70·00
Feed per revolution, in. ...	0·0016	0·008

Speed and feed were varied to suit the character of the forging, those here given being among those generally used.

While probably a little more power is required when work is rotated, this method holds the axis of hole true, even though the hole itself may be conical.

Boring.—Fig. 7 shows the forging ready for the boring operation in holes after drilling, and also cross-sections at subsequent stages. In the shop this was sometimes called "roughing-reaming." The most important feature of this operation is to get the hole as nearly straight as practicable. When the drills have not met exactly or within a few hundredths, this is difficult to do, especially in the small hole, for which the bar is but 1 in. in diameter and not stiff enough to keep the cutter running true.

The forging was held in a fixture very much like that used for drilling and secured to the carriage of the lathe, but the cutting tool was drawn instead of being pushed. The set-up for the large hole is shown in Fig. 8, the view being from the head end and the forging not in position. The double-end fly cutter is guided into the hole by the follower shown half-way out of the guide of the fixture. This follower does not leave the guide until its end next to the cutter has passed into the hole and is able to force the cutter to cut very nearly along the true axis. The outer sleeve on the follower is free to turn and is hardened and has a diameter across the lands 0·0008 in. less than that of the cutter. It was found that in spite of this follower, one roughing cutter would not true up the small hole very well when the drills did not meet. This led to the use of a leading cutter 1·375 in. in diameter and placed at right angles to the second cutter, and a better hole resulted.

Figs. 9 and 10 show the bars, cutters and followers respectively used in the small and large holes. The boring leaves the large hole 0·118 in. below final size, and the small hole 0·123 in. Mineral lard oil was forced through from the head end and carried the chips out through the grooves in the follower. In early efforts a cast steel follower, shown in Fig. 8, was used which had a series of hardened studs ground to the size of the hole, but this type of follower was soon discarded as it did not hold its size so well as the one with longitudinal ribs.

At first a reamer cutter was used of the form also shown in Fig. 8, this being a foreign type. It did not work so well due to the breaking down of the outer point on the cutting edge which led to seizing in the hole, as the original tool did not have proper relief back of the cutting edge. The preference abroad for this cutter is most probably due to the softer steel used.

At the end of the boring operations the holes are neither straight nor parallel. It will be noted that so far the piece has been set in two fixtures for drilling each hole and in one fixture for boring each hole, a total of six fixtures. The relation of the guiding surfaces of these fixtures to the centre of the drill rest and lathe spindle was made correct to about 0·001 in. for each

* Paper contributed by the Ordnance Division and read at the Annual meeting, New York, December 4 to 7, 1922, of the American Society of Mechanical Engineers. Abridged.

† U. S. Army. Mem.Am.Soc.M.E.

‡ Vol. liii (1920), pages 595, 937, 1049 and 1094.

machine by special fitting, but the clearance of the drill tube in the guide and deflection in working, plus the summation of machine differences, may easily amount to several thousandths of an inch; or the errors may compensate, leaving a smaller resultant error.

	First Bore. Small Hole.	Large Hole.
Size, in.	(2 cutters) 1·375, 1·456	2·48
Stock removed on diameter, in.	0·037, 0·081	0·118
Average time of operation, including set-up, hours	2	2
Feed per revolution, in.	0·015	0·015
Speed, r.p.m.	60	60

It is permissible to admit these errors in position up to this point. Their total will seldom exceed 0·05 in. and is ordinarily very much less. As will be shown, the reaming fixture is designed to correct or improve parallelism and straightness.

It is well to note here that after the set-up has been made on the machine for reaming about to be described, a second boring cut is made in each hole. For this 1·540-in. and 2·560-in. fly cutters are used, these removing respectively 0·074 in. and 0·08 in. of stock on the

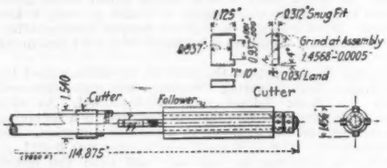


Fig. 9. BAR, CUTTER, AND FOLLOWER FOR THE SMALL HOLE

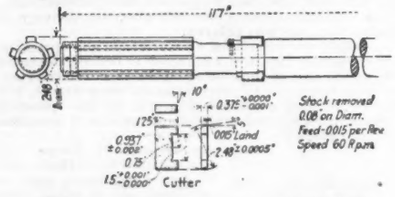


Fig. 10. BAR, CUTTER, AND FOLLOWER FOR THE LARGE HOLE

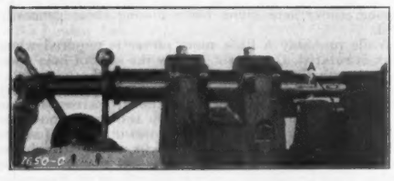


FIG. 11. SET-UP FOR FINISH-REAMING THE LARGE HOLE.

diameter. These cuts may be considered as either finish boring or rough reaming. They are not considered in the discussion of reaming below.

Reaming.—Reaming is the first operation that approaches precision, and the quality of the reaming affects very much the accuracy of lapping. After the rough-boring the piece is planed or milled practically all over; the surfaces being measured from the centre of the bored small hole. After reaming both holes, these surfaces are for the most part finish-planed or milled, being again located from the centre of small hole. In the reaming it is not necessary that the holes be located with extreme accuracy with respect to the planed surfaces as enough stock is left on these to finish up, but the reamer should leave the holes parallel, round, straight and smooth.

Fig 11 shows the set-up for reaming the large hole. The small hole has been finish-reamed and the piece is now trued up on centreing plugs which are expanded to fit snugly in each end of the small hole. The piece is supported and held in the fixture below it, which has adjustable bearing surfaces so that the plugs merely align the work but carry no weight. The axis of the bushing in the steady rest for the reamer, and the lathe spindle must be correctly and accurately located with respect to the centre line of the two plugs. In reaming the small hole the set-up is identical with that described for the large hole, the centreing plugs being adjusted to fit in the bored large hole. It is evident, therefore, that the exact relative positions of the holes and their degree of parallelism must depend on the parallelism of the reamer bar with respect to the centre lines of both sets of plugs. The piece being aligned on the plugs parallel to the reamer bar, the reamer is constrained by the packed head to cut on its proper axis, but not entirely so, since after the head leaves the guide it is not controlled except by the hole itself.

Two or more cuts are taken with wood-packed reamers of the kind shown in Figs. 12 and 13. The greatest care was taken with this reamer to see that it left a smooth finish free of all but the finest scratches. If defects were found in the steel, as frequently occurred, or if the reamer left scratches, one or more oversize reamers were passed. The first packed reamer leaves the large hole 2·584 in. or 0·018 in. under size, and the second or finish reamer cuts from 2·595 in. to 2·599 in. or 0·005 in. to 0·001 in., under the nominal maximum. In actual practice the character of steel in the forgings varied so greatly that it was found necessary to allow several oversizes, as this permitted re-reaming to remove defects.

The importance of a uniform and clean steel cannot be over-emphasised where it is necessary to produce all holes to the same size. Lapping, as practiced, did not straighten a crooked hole except to the extent later indicated, and as it is also a very slow operation it is highly important that the hole come from the reamer true and smooth. If it is not true it can only be partly straightened under the lap, and if scratched or rough more metal must be left for lapping or it must be lapped oversize.

In Fig. 11 the packed reamer head is seen leaving the guide and the cutter has not yet entered the hole. The plug is shown at A not fully entered into the small hole. The piece has been moved about 2 in. toward the lathe headstock in order to show these parts. In operation it is forced to the rear until the bushing of the guide, which has a lead-packed end, is in contact with the rear end of the piece and closes the hole, thus forming the oil

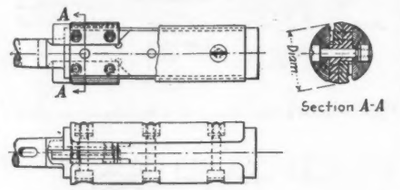


Fig. 12. WOOD-PACKED REAMER USED IN LARGE HOLE

(Ground to 2.584 in. diam. for rough-ream; to 2.599 in. for finish-ream; to 2.610 in. for 1st oversize. Tolerance = 0.0005 in.)

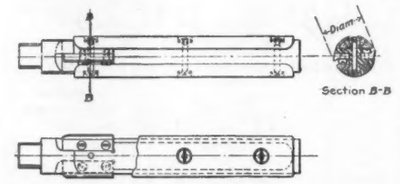


Fig. 13. WOOD-PACKED REAMER FOR SMALL HOLE

(Ground to 1.56 in diam. for rough-ream; to 1.575 in. for finish-ream; and to 1.585 in., 1.595 in. and 1.605 in. for 1st, 2d and 3d oversize ream. Tolerance, = 0.0005 in.)

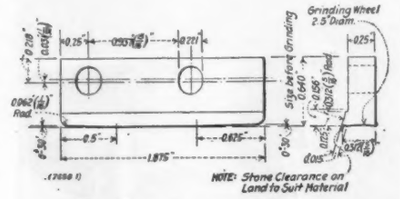


Fig. 14. DETAILS OF FINISH-REAMER BLADE

channel. Pure lard oil is fed through the pipe at B and passes through the bushing thence into and through the hole and out the front end around the tool.

	Small Hole.		Large Hole.	
	Rough.	Finish.	Rough.	Finish.
Size, in.	1·56	1·575	2·584	2·599
Feed per revolution, in.	0·025	0·025	0·025	0·025
Speed, ft. per min. ..	30–40	30–40	30–40	30–40
Stock removed, in. ..	0·02	0·015	0·024	0·015
Oil used	pure lard.	pure lard.	pure lard.	pure lard.

The wood-packed reamers were kept soaked in pure lard oil. The packing was turned to 0·002 in. above diameter of the cutter. The guides in the steady rest were hardened and ground to 0·001 in. above the diameter of the steel followers and were a snug fit over the packed reamer heads. Fig. 14 shows some of the more detailed characteristics of one of the reamer blades.

Attention has already been called to the importance of good reaming. It is necessary to select a steel for the reamer which holds its edge and does not chip off, as this may destroy a hole.

The blades must be ground with clearance and rake on the cutting edge, which are determined by experiment on the work, and the angles first given on the tool drawings may be used only as a preliminary guide. It was the practice to have one man specialise on grinding the blades and it cannot be said the practice was standardised. The cutting edge was usually given a tape of 30 minutes but this angle was varied to suit depth of cut or hardness of steel.

An experienced man can usually tell by holding his hand on the reamer bar whether the tool is cutting well, and chips should be smooth and well formed. If these indicate the cutting edge has broken down it must be immediately reground, and the cutting edge at the beginning of the taper carefully stoned.

Reaming should be continuous since a mark is invariably left after stopping, due to contraction of wood or other parts or substitution of a new reamer. The reamer must never be drawn out while the machine is running as this leaves a spiral line. The reamer blades should be set by a specialist, who also sees to correct grinding and to oil stoning after grinding.

Slag pockets are serious for several reasons; they may be too deep to remove, or they may destroy the finish by breaking down the cutting edge and cause scratches.

At the Singer Company's shops the large and small holes were bored and reamed in two settings of the work, one for each hole. For work on the small hole the piece was set in a fixture mounted on a 24-in. heavy-duty Pond lathe in somewhat the manner of the Rock Island method, and the boring and reaming tools drawn through in succession. They were guided at the beginning of the cut in a manner also similar. These features, however, were different: (*a*) No fly cutters were used, but the boring or rough-reaming was done with a reamer which required oil flow in a reverse direction. This is the type of reamer above referred to as having been discarded by the arsenal, but it is here used with success. (*b*) The holes were finish-reamed in two fixtures and the relative location of the holes with respect to each other would not seem to be so well controlled as by the Rock Island method, which mounts the piece on the locating plugs in the same fixture, but there are no data available to show whether this is true.

At the Singer Company's shops the large hole was bored and reamed in a revolving fixture like that used for drilling. It was proposed to do this drilling in the same manner as for the small hole, but fixtures were never completed.

(To be continued.)

THE KROMHOUT MARINE OIL ENGINE.—Messrs. Perman and Co., Limited, 82-83, Fenchurch-street, E.C. 3, have issued a pamphlet entitled "Ships, their Builders and the Kromhout Marine Oil Engine," which, as its title suggests, gives illustrated information on the Kromhout engine, its various component parts, the reversing gear, and on the numerous ships of different classes which are propelled by this engine, namely tugs, coastal boats, full power and auxiliary vessels, barges, launches and yachts. Chapters also deal with the fuel and with lubrication.

"THE VISCOSITY OF SLURRY IN THE CEMENT INDUSTRY." ERRATUM—The British Portland Cement Research Association write to us in connection with the article in our issue of the 5th inst. (page 19) on the research work of their Association, drawing attention to an unfortunate slip. In two places the expression "increase the viscosity" has been used by error, the real object of the work, as will be evident from the gist of the article, being to diminish the viscosity, so that a slurry containing a lower proportion of water can be handled as easily as the original slurry containing a higher percentage of water.

THE GORDON MEMORIAL COLLEGE.—The report and accounts to December 31, recently issued by the Gordon Memorial College, Khartum, points to the great progress achieved by this Institute in the general education of a large number of lads of the Sudan and neighbouring lands. The boys in the college at the commencement of 1921 numbered 798; most of them are also taught various crafts. The greatest care is given to their health, arrangements having been made for a thorough medical examination of all boys in the college to be held every year. The college committee and staff deserve all praise for the useful work they are carrying out.

MOVING IRON AMMETER OR VOLTMETER.—The moving iron meter of the Record Electrical Company, Limited, of Broadheath, Altrincham, Cheshire, particulars which reached us too late to be included in our article on the Physical and Optical Societies' Exhibition, is an instrument primarily designed for alternating current measurements, in which magnification is obtained in a novel way. There are two coils, arranged the one above the other. The lower coil contains a fixed iron, and a spindle carrying a movable iron. The upper coil contains a movable iron which is attached to an arm extended from the movable iron in the lower coil, and a second spindle to which is attached a moving iron carrying the pointer. The mechanism thus represents a combination of two moving iron systems. The fixed lower iron repels the movable iron adjacent to it; at the same time the two irons in the upper coil are repelled from one another; as the pointer-carrying iron is deflected, it is followed up by its adjacent repelling iron. When the lower iron is deflected through 1 deg., therefore, the pointer will move through 2 deg. The masses of iron are small. The instrument is also suitable for calibration as a direct-current meter, although for this purpose the firm has its Circscale permanent magnet moving coil instrument. The Circscale instruments are distinguished by the large arcs of their scales; the pocket set of the Circscale instrument measuring with five ranges, currents of 50 amperes and 250 volts maximum, weigh, complete with resistances and shunts, less than 2 lb.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

185,847. The British Thomson-Houston Company Limited, London, and A. P. Young, Kenilworth. Magneto-Electric Machines. (2 *Figs.*) June 13, 1921.—The invention relates to flywheels for use as the rotors of magneto-electric machines. The object of the invention is to provide a flywheel for such a machine which will be compact and strong in construction and efficient in operation. To that end it consists in providing laminated pole pieces 1 of magnetic material which are cast into a ring 2 of non-magnetic material of high tensile strength,

Fig. 1.

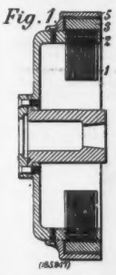
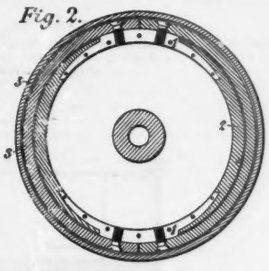


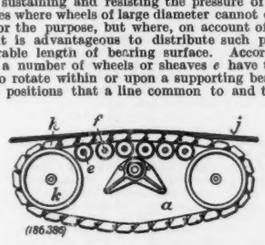
Fig. 2.



such as phosphor-bronze, the laminæ forming the pole pieces are securely riveted together and the ring of non-magnetic material is surrounded by two semi-circular permanent magnets 3, the ends of which are secured to the laminated pole pieces by means of screws. In order to prevent the possibility of the permanent magnets becoming dislodged during rotation at high speeds a second ring 5 of non-magnetic material of high tensile strength, such as phosphor-bronze, completely encases the two magnets, and may be fixed to the flywheel by means of screws projecting in a radial direction. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

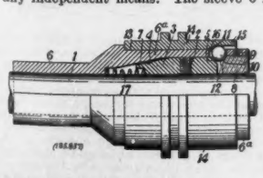
186,386. L. J. Roe, Finchley, Executrix of the late J. P. Roe, London, and Ropeways, Limited, London. Ropeways. (3 *Figs.*) May 27, 1921.—The invention provides improved means for sustaining and resisting the pressure of a travelling rope in cases where wheels of large diameter cannot conveniently be used for the purpose, but where, on account of heavy rope pressure, it is advantageous to distribute such pressure over a considerable length of bearing surface. According to the invention, a number of wheels or sheaves *e* have their axles *f* mounted to rotate within or upon a supporting beam or frame *a* in such positions that a line common to and touching the



peripheries of the wheels or sheaves will correspond to an arc of any desired radius or shape. *h* is a series of blocks so joined or connected together as, in effect, to constitute an endless loop. The outer surfaces of the blocks are adapted to receive the rope *j*, whilst their inner surfaces are adapted to bear upon or against the series of wheels or sheaves *e* carried by the frame or beam *a*. The endless loop of blocks *h*, after leaving and also prior to coming in contact with the bearing wheels or sheaves *e*, is arranged to work or be guided over tumblers or sheaves *k* mounted near the ends of the beam or frame *a*. (*Accepted October* 11, 1922.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

185,857. John Hetherington and Sons, Limited, Manchester, and J. Horridge, Bolton. Clutches. (2 *Figs.*) June 15, 1921.—The invention relates to clutches. 1 represents a shaft upon which is fixed a sleeve 3, which at one end is furnished with a gradual taper 4, and the other end is bevelled or chamfered at 5. Loosely mounted upon the shaft 1 is a sleeve 6 which is rotated by any independent means. The sleeve 6 is furnished



with a longitudinal extension 6*a* which embraces the sleeve 3 and is provided with an internal taper 7, which corresponds with that of the sleeve 3 and acts in conjunction therewith. The end of the extension 6*a* is open and internally threaded, and screwed thereinto is a ring 8 which embraces the shaft 1 with capability of sliding thereon. The ring 8 is provided with a chamfer 10. In the extension 6*a* are holes 11 within each of which and resting upon the chamfers 5, 10, is a ball 12. The periphery of the extension 6*a* is provided with a recess 13 in which is mounted a sliding sleeve 14. The end of the sleeve 14 has an internal recess 15 terminating in a taper 16. In the position illustrated, the clutch is in its open position, that is to say, the sleeve 6 rotates freely upon the shaft 1. Upon sliding the sleeve 14 towards the right hand, the taper 16 will strike the ball 12 and force the same inward towards the shaft 1. The movement of the sleeve is continued until the level portion of its interior surface bears upon the ball 12 and prevents it from moving away from the shaft 1. In its inward movement the ball 12, by virtue of the chamfer 10, acts upon the ring 8 in a cam or wedgelike manner and forces the ring 8 away from the sleeve 3, and as the ring 8 is fixed with the extension 6*a* it draws the same with it in its movements, thus bringing the inclined surfaces 4 and 7 into contact and clutching the sleeve 6 with the sleeve 3 and consequently with the shaft 1. In order to open the clutch, the sleeve 14 is moved to the left, when a spring 17 interposed between the ends of the sleeve 3 and the sleeve 6 will force the clutching surfaces 4 and 7 apart and at the same time through the extension 6*a* and ring 8 force the ball 12 outward into the recess 15 of the sleeve 14. (*Sealed.*)

185,772. F. H. Smith, Nottingham. Lathes. (4 *Figs.*) March 8, 1921.—The invention has relation to that type of lathe in which the lathe bed is composed of two parallel longitudinal rods or bars having a central longitudinal screw extending between them for traversing the tool rest. According to the invention, a lathe of the type mentioned is characterised in that standards or retaining members for supporting in the required relative positions the rods or bars forming the lathe bed, the central screw for traversing the tool rest, the lathe spindle and the tailstock are all cast from one and the same mould by utilising the complete mould and divided portions thereof, in a manner already known in connection with frames for associating machines in units, each of the castings produced having holes therein for accommodating the bed rods or bars. The complete casting *a* produced from the mould is of isosceles triangular configuration, as shown in Fig. 2, and is formed with a hole 1 near the apex and two holes 2 equi-distant from the perpendicular line dividing the base 3 and situate between the apex and base, the centres thereof being contained within one and the same line parallel with the base 3. Such casting constitutes a standard for a lathe as shown in Fig. 1, the hole 1 accommodating the lathe spindle 4

Fig. 1.

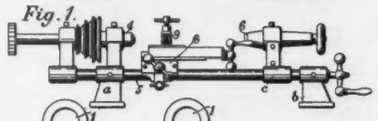


Fig. 2.

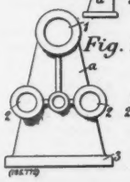


Fig. 3.

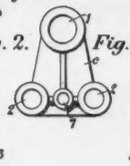


Fig. 4.

and the holes 2, the rods 5 constituting the lathe bed. The rods 5 are accommodated at the tailstock end of the lathe by a second casting *b* (Fig. 4), which is a replica of the lower half of the first casting *a*. The opposite extremities of the rods 5 are accommodated in a third member, Fig. 3, produced from the same mould, which member has formed therein the holes 1 and 2, but is cut off just below the holes 2. Such casting *c* is therefore a replica of the first casting *a* with the base removed, and the hole 1 near the apex accommodates one end of the lathe spindle 4. The casting *a* from the complete mould is situate between the two castings *b* and *c* (*i.e.*, the second and third castings described), such latter castings though produced from one and the same mould performing different functions. The tailstock of the lathe is a replica of the third casting *c*, the hole 1 near the apex accommodating the centre 6 and the holes 2 accommodating the rods 5. A fourth hole 7 is formed in each of the castings *a*, *b*, *c*, said hole 7 being centrally disposed between the holes 2. This hole 7 accommodates a screw-threaded rod (not shown) extending centrally along the length of the machine with its axis in the horizontal plane of the axes of the rods 5. The central screw engages with an internally screw-threaded part of a tool slide rest 8 carrying tool holders 9. (*Sealed.*)

MINING, METALLURGY, AND METAL WORKING.

185,844. C. R. Norwood, Richmond, and W. A. Naish, Putney, London. Casting Metals. (7 *Figs.*) June 11, 1921.—The invention relates to hand-pouring or gravity-fed moulds or dies for casting the ferrous metals. According to the invention, electrical resistances are applied to recesses in or are embedded in the walls of hand-pouring moulds, and the moulds, which are heated electrically in a fixed position, are

Fig. 1.

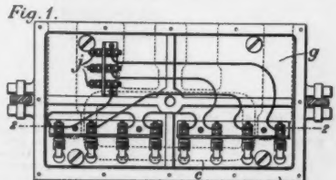
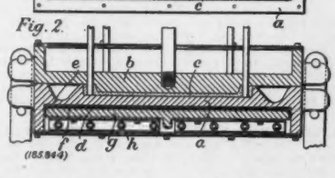


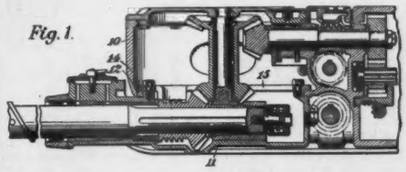
Fig. 2.



fitted with permanent operating devices for withdrawing the pins used for forming holes in the casting, for opening and closing the moulds and for ejecting the moulded articles. The mould is shown made in two parts *a* and *b*, and *c* is a casting in the mould. Sheets of mica *d* and *e* have between them strips of insulating material *f* upon which the heating strips or resistances are wound and the sheets of mica *d* and *e* are held in position by pressure plates *g*. The ends of the strips or resistances pass through the plate *g* to terminals *h*, which are connected to three other terminals *j* as shown in Fig. 1. The terminals *j* are connected to a switch by which the amount of current is regulated. (*Sealed.*)

185,837. M. S. Moore, London, and Cowlishaw, Walker and Co. (1920), Limited, London. Coal Cutters. (3 *Figs.*) June 10, 1921.—The invention relates to coal-cutters of the type in which the cutting arm is carried by a circular body portion which has swivelling engagement with, or is mounted to rotate in the gearhead, this body portion being commonly known as the "banjo." The invention has for its main object to provide a construction whereby the division of the gearhead into two parts is avoided, whilst providing means within the gearhead for readily separating the banjo portion from the gearhead. According to the invention, there is provided in a coal-cutter, a banjo 11 so shaped as to spigot in an inwardly-directed flange 12

Fig. 1.



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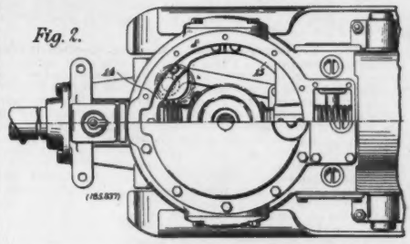
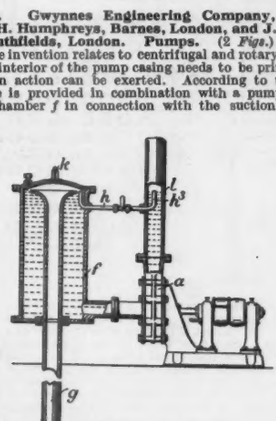


within the gearhead 10, and a ring 14, 15, that is divided diametrically and is secured (*e.g.*, by bolts) within the gearhead 10 on the spigot end of the banjo. The ring 14, 15 overlaps the flange 12 so as to retain the banjo in engagement with the gearhead. The gearhead is provided with one or more openings (with or without detachable cover plates) to permit of access to the bolts and the insertion or removal of the ring. It will thus be seen that by removing the cover plates, if these are employed, the fastening means of the divided ring 14, 15 can be removed, and then the separate parts of the ring can be withdrawn through the opening provided by the cover plate. This leaves the banjo portion free to be removed bodily downwards from the gearhead. (*Sealed.*)

PUMPS.

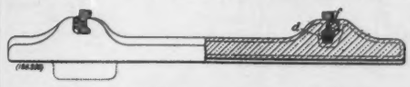
185,853. Gwynnes Engineering Company, Limited, London, H. Humphreys, Barnes, London, and J. J. Pressman, Southfields, London. Pumps. (2 *Figs.*) June 14, 1921.—The invention relates to centrifugal and rotary pumps, in which the interior of the pump casing needs to be primed before the suction action can be exerted. According to the invention, there is provided in combination with a pump *a* and a priming chamber *f* in connection with the suction pipe *g*, a



bye-pass pipe *h* connected between the priming chamber *f* and the delivery pipe *l* of the pump, and formed or fitted at the end in the delivery with an upward bend h^3, or with a cone or nozzle, so that the delivery acts inductively upon the bye-pass for the purpose of removing air which may accumulate in the priming chamber *f*. Also an automatic air relief valve *k* may be provided on the priming chamber *f* for permitting of the relief of any air pressure that may arise in the chamber at any time. (*Sealed.*).

RAILWAYS AND TRAMWAYS.

186,356. R. Addison, Willoughby, near Alford, and C. A. Guttridge, Ashford, Kent. Reinforced Concrete Railway Sleepers. (5 *Figs.*) October 15, 1921.—The invention has reference to reinforced concrete railway sleepers of the type in which jaws adapted to form rail chairs are formed in one with the sleeper, the rails being secured between the jaws by keys



or wedges. According to the invention, a reinforced concrete sleeper of the type referred to is provided in the bottom of the space between the jaws forming a rail chair with a block or pad of wood *d* upon which the rail *f* rests, a metallic liner being sandwiched between the rail and the block. (*Accepted October* 11, 1922.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

182,556. H. P. Bray, London, and H. A. Stenning, London. Steam Superheaters. (2 *Figs.*) April 2, 1921.—The invention relates to steam superheaters for use with locomotive boilers. The invention comprises a superheater wherein each header consists of an open frame-like structure which completely surrounds the extended axes of the flue tubes. The superheater is shown applied to a locomotive having three rows A,

Fig. 1.

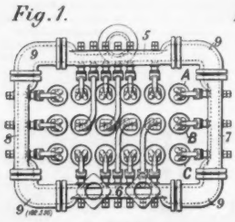
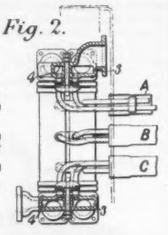


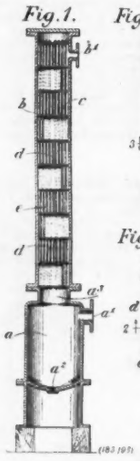
Fig. 2.



B and C of superheater flue tubes with six tubes in each row; the header formed as a frame and comprising saturated and superheated steam chambers 3, 4 is mounted so as to surround the extended axes of the flue tubes. The header is made up of four portions 5, 6, 7, 8. These four portions are connected by corner pieces or elbows 9. The ends of the elements projecting from the flue tubes are connected to the horizontal and vertical portions of the header. (*Sealed.*)

183,195. E. Barrs, London. Cooling, Condensing or Heating Apparatus. (4 *Figs.*) April 6, 1921.—The invention relates to cooling, condensing or heating apparatus of the type wherein the heating or cooling medium is made to pass between tubes, or a substance to be cooled is passed between rods, which tubes or rods extend through a series of compartments separated by partitioning plates each having an opening, one to provide an inlet to the compartment between any two plates, and the other an outlet. According to the invention, cooling, condensing or heating apparatus of the type described is provided with baffles situated in planes at right angles to those of the partitioning plates in such way as to project between the inlet and outlet openings of the compartments, and thereby cause the gases to travel round the chambers containing such baffles as well as across the same. A cylindrical bottom collector chamber *a* has a side inlet a^1 for gas, a small central opening a^2 in the bottom to drain off the collected material, and a central flanged

Fig. 1.



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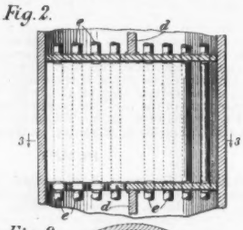
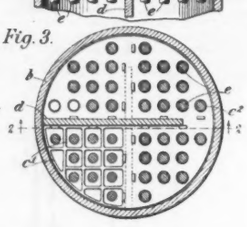
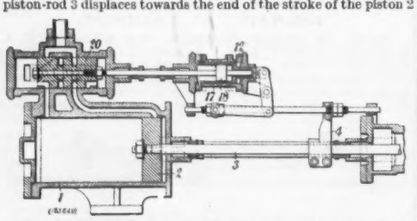


Fig. 3.



opening a^3 at the top through which the gas to be cooled may pass. Surmounting the chamber *a* is a cylindrical casing *b* which has a side outlet b^1 through which the cooled gas may pass. Within the casing is a series of horizontal partitions *c* with vertical baffles *d* interposed between them. Passing through the partitions and extending from the uppermost of them to the lowermost are straight rods *e*. Each partition is provided with a number of large apertures c^1 forming substantially a quadrant-shaped opening in the plate, the rods *e* passing through these apertures but by no means filling them. The remaining rods *e* loosely pass through the plates *c*, the perforations c^2 to receive them being of larger diameter than the rods. The baffles *d* are in breadth about three-fourths of the internal diameter of the casing *b*. The baffles are disposed alternately at right angles to one another throughout the column. With the baffles disposed thus the gas, as it passes through the column, has to take a spiral path. (*Sealed.*)

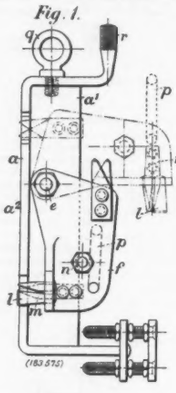
183,649. F. Morton, Low Moor, Bradford. Valve Gears. (1 *Fig.*) May 27, 1921.—The invention relates to valve gear for fluid pressure engines of the type in which a tappet 4 on the piston-rod 3 displaces towards the end of the stroke of the piston 2



a valve controlling the entry of fluid to one or other end of a cylinder 17 in which a piston 18 slides, which latter piston is connected to the valve 20 controlling the entry and outlet of pressure fluid to the main working cylinder 1. According to the invention, the main control valve 20 for the fluid pressure engine is displaced from one end position to another by means of the piston 18 moving within a cylindrical sleeve 12, which is ported to act simultaneously as a sleeve valve and as a cylinder. The cylindrical sleeve 12 is moved from one end position to another end position by the tappet 4 connected to the main working piston 2. (*Sealed.*)

183,575. H. C. Smith, Waterloo, near Liverpool. Removing Incrustation or Scale. (8 *Figs.*) April 26, 1921.—The invention relates to an appliance for the removal of the incrustation or scale from boiler plates. *a* is a bracket extending transversely through a middle web a^1 of which is a shaft *e* upon which is pivotally supported at each side of the web a^1 a plate *f*. On each plate *f* steel cutters *l*, *l*, *m* are secured. A plate *f* is of such weight, and its point of pivoting on its shaft *e* so determined, that the lower portion tends to project itself beyond the face a^2 of the bracket *a*. The plates *f* are coupled together by a rod *n*.

Fig. 1.



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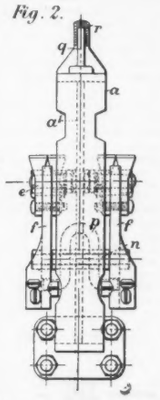
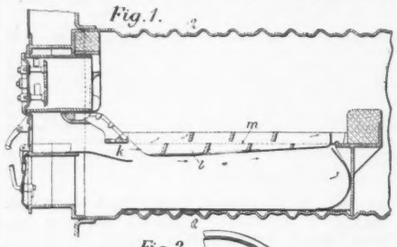


In use, the appliance is lowered into the combustion chamber to be cleaned, *i.e.*, between the combustion chamber back and the boiler end plate, by means of a rope, an end whereof is secured to the eyebolt *q*; the appliance is then canted or tilted by means of a jointed or telescopic rod secured to the arm *r*, so that it shall be firm and rigid, when positioned. A rope, an end whereof has been secured to a shackle *p*, is pulled to raise the cutter-carrying plates *f* about the shaft *e* to the position shown in dotted lines, Fig. 1, and then released, when the plates with cutters return under the action of gravity and strike—as hammers—the plate to be cleaned, and so remove the scale or incrustation. (*Sealed.*)

183,508. J. Reid, London. Furnaces. (3 *Figs.*) February 24, 1921.—The invention has reference to means for ensuring the more even passage of air through furnace grates and consequently more uniform combustion of the fuel. A furnace, according to the invention, has the space immediately beneath the grate divided by a number of longitudinal walls or partitions *l* having lateral flukes or palms so curved or inclined upwardly and rearwardly as to deflect air upwardly and forming between them longitudinal passages open at the bottom, the walls or partitions *l* being spaced apart and having intermediate of them shallow grate bars *m*. The flukes or palms are of such sizes and so spaced apart longitudinally as to tend to cause an equal flow of air through all parts of the grate and thus reduce the liability of air to flow in greater proportion through the rear

Fig. 1.



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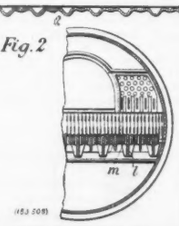
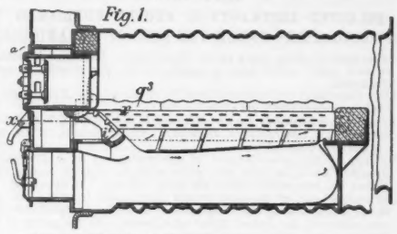


part of the grate and, as the walls or partitions check the flow of air between them more or less sideways to beneath those parts of the grate which are thinly covered with fuel, the flow of air through the grate above each passage or channel is rendered more uniform from end to end, and an area of low-pressure above the front part of the grate is thereby avoided, with the consequent tendency for the gases to surge towards the front end of the furnace and confuse the flow of air and gases towards the back end. The walls or partitions rest upon and are secured to a plate *k* extending partly across the furnace from below the level of the sill; the rear ends of the walls or partitions are attached to a cross-bar or plate supported on the side walls of the furnace or by a bridge which may also act to deflect air through the fire bars. (*Sealed.*)

185,784. J. Reid, London. Furnaces. (6 *Figs.*) April 12, 1921.—The invention has reference to the furnaces of Scotch and other steam boilers having internal furnace tubes. According to the invention, there are employed at the sides of the grate, longitudinal chambers g^5 which prevent the fuel coming into contact with the furnace tube walls and at the front end of the grate, a hollow dead plate *i*, which chambers and dead plate are perforated or slotted and receive and deliver air into the fuel on the grate at or just above the level of the grate bars. The fuel is thus contained in a sort of trough and receives supplies of air for combustion through the front and sides thereof as well as through the bottom, which effective distribution of the air enables energetic combustion to be maintained throughout the fuel bed without the total amount of air supplied exceeding to the usual extent that required for combustion. The side chambers and

Fig. 1.



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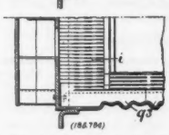
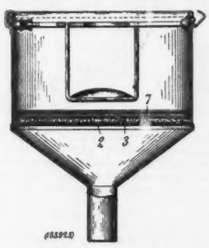


the hollow dead plate or equivalent may be fed with air from the ash pit direct, or from side chambers formed in the ash pit space, or through apertures in the furnace front. (*Accepted September 27, 1922.*)

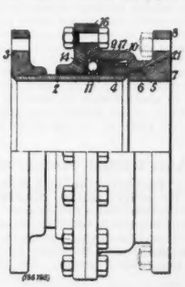
MISCELLANEOUS.

185,925. G. Anderson, Wandsworth. Liquid Straining or Filtering Apparatus. (2 *Figs.*) August 2, 1921.—The invention relates to liquid straining or filtering apparatus for a volatile liquid, such as petrol. The patentee has discovered that by passing a volatile liquid, such as motor spirit, containing water through a fine-mesh screen having supported thereunder, and a short distance therefrom, a pad of absorbent material, the volatile liquid will pass through the screen while the water



will remain on it. According to the invention, therefore, there is combined with a fine mesh screen 7 a pad 3 of absorbent material supported a short distance therefrom. The absorbent material may be cotton-wool, asbestos or the like. A convenient support for the pad 3 comprises a second fine mesh screen 2 and a convenient form of the invention constitutes means for introducing liquid into a container, for which purpose it is constructed of funnel shape. (*Sealed.*)

186,166. W. H. Dorman and Co., Limited, Stafford, and O. H. Steed, Stafford. Pipe Joints. (1 *Fig.*) June 24, 1921.—The invention relates to rotatable pipe joints of the kind in which the relatively rotatable elements extend one within the other and are connected together by means which comprise essentially a ballbearing for taking the end thrust between these elements incidental to the fluid pressure within the pipe line and a U section washer interposed between an internal periphery on the one element and an external periphery on the other element in such manner as to resist such fluid pressure and provide a fluid-tight connection between the two elements. The invention consists essentially in the arrangement according to which an annular abutment rigidly mounted upon the inner element constitutes at once one element of the ball race and a support and protection for the U-section washer. 2 is a pipe of which one end is screwed and expanded into a flange 3 adapted to be connected to the end of one of the pipes to be joined. At



the other end of the pipe 2 is a sleeve 4 formed at its end as an annular projection 5 to extend into an annular recess 6 formed in the second member 7 of the joint. The outer end of the member 7 is provided with a flange 8 similar to the flange 3, and this member 7 is constructed with an enlarged portion 9 extending over the end of the pipe 2 and forming a recess to accommodate a U-shaped packing ring 10 located between the inner surface of the enlarged portion 9 and the outer surface of the sleeve 4. The sleeve 4 is provided at the end opposite to the projecting rim 5 with a flange 17, between which and a closing plate or flange 14 bolted to the flange 16, is a thrust ball bearing 11. A series of holes 21 is arranged circumferentially in the sleeve 4 in such a manner as to allow fluid under pressure to pass from the pipes to the inside of the U-shaped ring 10. The pipes to be joined are connected to the flanges 3 and 8 at each end of the joint as a whole, and can be relatively rotated at will even though there is considerable pressure within the pipe line. (*Accepted October 4, 1922.*)